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ABSTRACT

Education reform is an ongoing process that requires a major commitment over a long period of time. This volume, the second in a series of three, presents case-study findings of a 4-year research project on curriculum reform, with a focus on science education, mathematics education, and higher order thinking across the disciplines. The study, the Curriculum Reform Project, explored the nature of various reforms, the barriers to reform, and the means by which schools met challenges and achieved positive change. The volume contains the full report of nine case studies of middle and senior high schools engaged in educational reform--three in science, three in mathematics, and three in higher order thinking across the curriculum. Each school profile describes the site context, data collection, details of the reform curriculum in practice (implementation, student learning goals, course content, teacher and student roles, and issues of assessment), and the context of change. Each profile also includes references. (LMI)

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FINAL TECHNICAL RESEARCH REPORT:

STUDY OF CURRICULUM REFORM

VOLUME II: CASE STUDIES

RONALD D. ANDERSON, PROJECT DIRECTOR

UNIVERSITY OF COLORADO

BOULDER, COLORADO

August 31, 1995

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A. PREFACE

As the educational reform efforts of the eighties carried on into the nineties, the Office of Educational Research and Improvement launched a program of research studies which addressed various facets of educational reform. The research reported here is the result of one of 12 such studies initiated by that Office in 1991.

The focus of this four-year research project has been curriculum reform, with specific attention to the three areas of science education, mathematics education, and higher order thinking across the disciplines.

Significant curriculum change is more than a curricular matter; it extends into most other facets of schooling, including teaching, learning and the culture of the school. Major change demands the attention of parents as well as the full range of school personnel.

As past research--and this study--shows, educational reform is an ongoing process and seemingly never complete. It requires a major commitment over a long period of time. This study tells this story in considerable detail, including the nature of various reforms, the barriers to reform encountered, and the means by which challenges were met and positive change achieved.

The report of this research is contained in three volumes: I. Findings and Conclusions, II. Case Studies, and III. Technical Appendix: Research Design and Methodology. This volume (II) contains the full report of nine case studies of schools engaged in educational reform: three in science education, three in mathematics and three in higher order thinking across the disciplines. The reader wishing more background information on the case studies, as well as the results of a cross-site analysis of all nine cases is referred to volume I.

This report is presented with the expectation that it will be helpful to others pursuing educational reform, whether they be policy-makers, practitioners, parents or researchers. With it go best wishes to all in the quest for improved education.

Ronald D. Anderson
Boulder, Colorado
June 1995

B. ACKNOWLEDGEMENTS

A four-year project of this size requires the participation and support of many people. A debt of gratitude is owed to many people including those acknowledged below.

The first acknowledgement is to Mary Ann Varanka-Martin who served as associate director of the project during its first two years and returned to help at some key points in the project's final stages. She played the major role in organizing a national conference held in 1992, and managed much of the process of identifying study sites and gaining access to them.

Major investments of time were made by the staff researchers who conducted the case studies, including Kathleen Davis, Maurene D. Flory, Elizabeth Meador, Beverly Anderson Parsons, Stephanie Quate, Lew Romagnano, Erin Rosen and Joan M. Whitworth. Each person had a particular site to study, requiring several weeks on site in the assigned school and, of course, a long time "on the road." Analysis and writing was considerably more time-consuming. In addition to their impressive professional competence, their dedication and positive outlooks created a great collaborative working context.

In addition to conducting their individual case studies, Beverly Anderson Parsons and Lew Romagnano each provided leadership for one of the three components of the study--Beverly Anderson Parsons for thinking across the disciplines and Lew Romagnano for mathematics education. Their intellectual leadership was of great importance to the project. (Leadership for the science education component was provided by the project director, who also conducted one of the nine case studies.)

Hundreds of students, teachers, administrators, parents and other personnel connected with the schools we studied welcomed us, graciously shared with us their time and insights, and were patient with our quest for understanding. Memories of our time with people in these schools are pleasant indeed.

The many people who nominated educational reform sites for our consideration--and the personnel in these sites who provided further information for us--were important to our work. Their help is appreciated.

Our project's program officer at OERI, Judith Segal, played an influential role in shaping the project. Her reviews of our work were always insightful and helpful and she made the relationship between research group and funding agency positive and productive.

Our advisory group shared many valuable insights with us. Not being part of the working staff, however, they cannot be held responsible for what we did with their advice. They include:

Bill G. Aldridge, National Science Teachers Association
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Ivette Torres, National Education Association

Margaret Eisenhart, a colleague at the University of Colorado, also served as an advisor to the project. Her insights and understanding of qualitative research made substantial contributions to our work.

The different formats of the original case reports were efficiently and effectively edited by Zaretta Hammond into a common format. Her skillful and timely work is much appreciated.

Other personnel at the University of Colorado, including secretaries Linda Webster and Bernice Moon, administrative assistants Patty MacDonald and Sue Middleton, Associate Dean Marc Swadener, and Dean Philip DiStefano each supported the project in important ways. Their support is most appreciated.

Many thanks to all.

Ronald D. Anderson
Project Director

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D. CASE STUDIES

CASE STUDY OF FRUITVALE HIGH SCHOOL MATH DEPARTMENT

ELIZABETH MEADOR
CURRICULUM REFORM PROJECT
UNIVERSITY OF COLORADO

1995

This paper was prepared for the Curriculum Reform Project, a study of curriculum change in mathematics, science and critical thinking which is funded by a grant from the U.S. Department of Education's Office of Educational Research and Improvement (OERI Grant #R91182001). The opinions expressed herein are those of the author.

FOREWORD

When faced with a challenge, a detailed story of someone else's experience in a similar situation generally is of strong interest. In reading someone else's story--be it political history, a chronicle of dealing with a family tragedy, or the story of a major business success--we do not expect to find a formula to apply directly to our own situation; instead we hope to find insight and inspiration. Thus, the story contained in this report should be engaging to individuals committed to educational reform in a local school context. It is the story of one school--or department within a school--engaged in fundamental reform of education for its students.

Similarly, one should not expect to find in this case a model for a specific educational reform to initiate in another locality. Every context is different. Each local school and community culture has its distinctions, each individual's and group's educational goals have different shadings, each setting has its own history, and each school has unique constraints to making change.

Not only does one formula not fit all schools, there is no specific formula for a given school. A central message of our case studies is that educational reform is a long-term process for which there is no detailed road map. It is an uneven process with highs and lows, failures and successes, but gradual movement toward greater and more profound learning for students.

What we can expect to find in this story are insights about new teacher roles, how students go about learning with greater depth of understanding, the context in which such shifts can occur, the challenges that must be overcome to initiate these changes, and actions taken by various parties to keep the process of change moving forward. Reflecting on someone else's story can be helpful in the process of developing one's own plans, collaborating with others to move the process forward, and helping students take responsibility for learning.

The Research Project. The case study reported here is one of nine--three each in science, mathematics and higher order thinking across the disciplines--conducted as part of the Curriculum Reform Project. The cases were studies of individual schools--actually a department within a school in the case of science and mathematics--in the process of solidifying reform. Each was selected because it was a successful example of reform. A researcher spent 20 or more days at the site to learn what changes they were making, the barriers encountered, how they overcame these challenges, the nature of their successes and their hopes for the future.

Site Selection Criteria. Sites were sought which had initiated reforms consistent with those recommended by leading groups in the respective field, e.g., the Curriculum and Evaluation Standards for School Mathematics (Commission on Teaching Standards for School Mathematics). Final selections were based on program outcomes including student test scores, enrollments in subsequent elective courses in the given subject area, and professional judgments about the quality of the curriculum provided to students.

Site Selection Process. The search process began with the solicitation of nominations from researchers and knowledgeable practitioners across the U.S. Key people at the nominated schools were contacted by phone to get additional information and written exchange of information followed. Selection according to the above criteria resulted in schools spread across the country with considerable variation in location (e.g., urban vs. rural), economic level and ethnic makeup of the communities.

Research Methodology. In each case the researcher was immersed in the activities of the school and collected a wide range of information. Data included classroom observations, interviews with students, teachers and administrators, and a variety of documents from the site. The voluminous field notes and interview transcripts were analyzed and an interpretative report written.

Cross-site Analysis. A cross-site analysis of the nine cases was conducted to gain perspectives that extend across the sites. An individual case is rich in description and context but does not contain the depth of analysis that can come from looking across a number of cases. Thus, the reader is referred to the Project's cross-site analysis. Main points from this analysis to bear in mind while reading this one case, however, include the following:

- The reforms being sought are profound and demand major changes in teacher and student roles.
- The process for achieving such reforms is complex and demands a long period of time to attain.
- The schools in these cases have traveled a considerable distance on the road to reform but have not yet "arrived."

These cases are presented largely--though not exclusively--from the perspective of the teachers at the center of the cases. This perspective reflects the nature of the reforms and the way they have been initiated in each school. This perspective may be particularly important for initiating change. Our cross-site analysis shows that changes in teachers' values and beliefs--not just greater teaching skills and techniques--are central to reform. While changes in student roles and student work are the ultimate "bottom line," these teacher changes are an important intervening step.

We hope your reading of this case stimulates both interest and significant reflection about reform activities in your school.

Ronald D. Anderson
Director, Curriculum Reform Project
University of Colorado

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I. INTRODUCTION

The nature of curriculum reform in mathematics is a fabric woven with many strands. This case study describes several of those strands from the perspective of those most intimately involved with mathematics education on a day to day basis, teachers and students. This is the tale of a high school mathematics department that had been struggling with curriculum change since 1980. These teachers began their struggle without the benefit of the current literature to which we now have access regarding school reform. No one handed them a set of cutting edge curricular materials and said, "Here, implement this. It's all ready to go". There was no principal well-versed in the rhetoric of school restructuring to lead them through the many steps to effective schools. The motivation to change was theirs, and theirs alone. This examination of that struggle asks, what does a teacher-made reform look like? What were the forces and influences that drove and shaped this effort?

The Site

This site was chosen because of its long history of reform in math education. In addition members of the staff at this site had been involved for some time in a variety of professional development activities, including attendance at several nationally known teacher development projects for math educators.

The architecture of Fruitvale High School resembled the stark, straight lines that dominated new building construction in the 1950's. It was a large, multi-level building, divided inside by stairways and corridors. The math department sat on the east end of the building and utilized classroom space upstairs, above the library, as well as downstairs in a small corridor.

The school hosted grades nine through twelve, while four feeder middle schools encompassed grades six, seven, and eight. There were ten departments at Fruitvale High School and eighty-five persons on the faculty. The building administration consisted of a principal and two vice-principals; there were three academic counselors. Support at the district level was in the form of a management team, that included a curriculum manager and three curriculum directors: one secondary curriculum director, one middle school curriculum director, one elementary curriculum director; a director of evaluation and assessment; an assistant superintendent; and a superintendent. The annual budget of the school district was roughly $80 million dollars.

Traditionally, Fruitvale High School was all white and had a local reputation as a college prep school. Its location at the western edge of town provided it with a student population from the west valley, a predominantly white area. An English as a Second Language (ESL) teacher from the school commented that three years ago there were five students in the ESL program, and that now there were 125. An overall growth in the Hispanic population in schools in the Fruitvale valley was due to a new trend among migrant workers. Traditionally they moved on after the fruit picking season was over, but now many choose to remain in the valley year round. The current school population of 1600 students was 25% Hispanic and 75% Anglo. The changing demographics raised questions regarding how to best meet the needs of a diverse population at all levels of mathematics.

	FRUITVALE COUNTY	FRUITVALE CITY
Population	188,823	54,827
% White	69.90	78.40
% Hispanic	23.91	6.30
% Nat. Am.	4.10	1.70
% Black	1.00	2.20
% Asian	0.90	1.20
% Other	0.20	0.20

This site was unique in that the reform efforts were a result of movement from within the department of mathematics. Other departments at this high school were relatively conservative, and the principal described himself as a "traditionalist who is uncomfortable with change." Thus the impetus to change and improve came from individual teachers of mathematics rather than state, district or administrative mandates.

Data Collection

Data collection for this study included participant observation; interviews of students, teachers, administrators, former faculty members and community members; a personal journal; collection of documents from the math department, the central office of the school, as well as the administrative offices of the district; and collection of artifacts such as exams, projects, and journals produced by students and math teachers at the high school.

Field work involved attending the mathematics classes, which differed in nature both by teacher and class period. Due to the variety of classes taught at each grade level, there were approximately eighteen different types of courses offered each trimester. While in the classes, observations were made of the behaviors, interactions, and conversations of both students and teachers. All the math teachers and a variety of students from different types of classes were interviewed. Also interviewed were school administrators and district administrators. In addition, the researcher informally interviewed community members in the town of Fruitvale.

Documents collected included items teachers thought the researcher should have, as well as items discovered while on site. Also collected were a variety of curricular materials, examples of assessment tools, district course descriptions, statements of philosophy and examples of student work.

Historical Context

To understand the nature and context of the reform at Fruitvale High School, two levels must be considered: the nature of the reforms that have been occurring at a national level since the 1970's and the influences of the national reform agenda on individuals at Fruitvale High School. Through attendance at various state and national mathematics conferences, key individuals at Fruitvale High School became members of informal networks of mathematics educators from around the country. Participation in networks of mathematics educators provided support for continued emphasis on gathering new ideas and curriculum for use in the classroom.

Reform in Math Education. In some sense, the history of mathematics reform at Fruitvale High School paralleled the reform of math education that has been occurring over the past 20 years at a national level. In the 1970's, a confluence of ideas produced an impetus for the reform of math education. The "new math era" of the 1960's was seen to have failed as educators saw students' test scores fall and conceptual understanding falter. The pendulum began to swing towards a "back to the basics" movement in the 1970's. This "back to the basics" movement then led to the current focus in mathematics education on conceptual understanding, which was seen as a weak point in the "back to the basics" movement. This pull between the "back to the basics" emphasis on factual knowledge and the emphasis on conceptual knowledge had been an unresolved struggle nationally as well as in the mathematics department at this site.

The following section will describe the intertwining relationship between key individuals involved in the reform of mathematics curriculum at Fruitvale High school and the implementation of materials and programs at this site.

History of Math Education Reform at Fruitvale. In 1980, an Agenda for Action was published by the National Council of Teachers of Mathematics calling for math education to reflect new understandings about learning, i.e., that math should be taught in the context of problems which students could solve using a variety of strategies. Around this time, two of the teachers of math at Fruitvale High School, Howard Roseberry and Ted Wolfe, were trying to develop an alternative program for kids who fell out of math when they got to geometry in the course sequence. Roseberry and Wolfe wanted to try non-traditional ways of teaching using integrated materials. For example, they developed curriculum materials for geometry which reduced emphasis on formal proofs, included trigonometry and computers, and used geometric figures to solve algebraic problems. Mr. Roseberry explains the thinking behind Wolfe's and his efforts:

> Ted and I worked together to implement new things. We convinced the district to let us limit class size in these classes to 22. And then we had to argue pretty hard to convince the district that our strongest teachers should be teaching the lowest classes. We had to convince them that the best teachers could explain things in a variety of ways, not just the way they had learned it. We had

> several years of success when I was asked to join the state math council to write the standards for the state. I really pushed for the middle group who were dropping out; that's where we needed to make changes.

In addition to developing curriculum materials for geometry students, Roseberry also changed the way general math, what he calls "bonehead math," was taught:

> As you can imagine, bonehead math is pretty boring. We needed to beef up the whole program. We started using calculators which was unheard of back then and we disguised skill learning in higher level problems which allowed the kids to think, but also practice their fractions if they needed to practice their fractions.

In 1984, when a third change-oriented teacher, John Davis, joined Mr. Roseberry and Mr. Wolfe at Fruitvale High School, the publication "A Nation at Risk," describing the state of our nation's schools as a crisis in education, had been in circulation for a year. Mathematics educators began developing a set of curricular standards that they hoped would assist the evolution of math education. Mr. Wolfe attended a national leadership institute in 1986 that was designed to develop leaders for curriculum reform in mathematics. This four week institute is held each summer for fifty math teachers who are selected from applicants around the United States. Following the four week experience, Mr. Wolfe was chosen to lead one week institutes in schools around the country.

Through these activities, Mr. Wolfe worked with several math educators from the North Carolina School of Science and Mathematics, a public boarding school for the brightest high school juniors and seniors in science and math from around that state. The staff at this school was developing a new curriculum in pre-calculus for their students. At the same time, the teachers at Fruitvale High School were concerned that the kids who were in the honor's track were entering calculus with a weak background in conceptual understanding of mathematics. Mr. Wolfe asked to test pilot the pre-calculus materials at Fruitvale High School. "Piloting the North Carolina materials really changed me," Wolfe explained. "I was team teaching with John Davis, and we were holding each other's hand. Teaching the North Carolina materials made me see math in a different way. I realized it could be done differently."

Davis, Wolfe, and Roseberry, all of whom had won awards for the teaching of mathematics, worked together at Fruitvale High School for three years. Those years were important in that there was a common vision among three strong players who saw the need to redefine the body of knowledge that is called mathematics. They became passionate about creating curriculum that was rich and contextual and contained opportunities for students to discover mathematics. This vision set the tone for the mathematics curriculum at Fruitvale High School.

At the same time, on a national level, the National Council of Teachers of Mathematics (NCTM) was preparing to publish their standards for mathematics curriculum. The standards were described as an organized response to the publications "A Nation at Risk" and "Educating Americans for the Twenty-first Century" (Romberg, 1993). The purpose of the standards was to provide a framework for the K-14 mathematics curriculum, and to call for a significant revision of the way in which mathematics was taught. These external forces shaped the reform at this site, as these three strong individuals participated in the national dialogue through informal networks of mathematics educators and attendance at national conferences for mathematics educators, and brought that dialogue back into their school.

Their passion was contagious, and the culture of the math department became one of willingness to risk, to write grants for funding, to try new materials and to involve kids in mathematics. The legacy of that passion was a computer laboratory devoted to an extensive library of mathematics software, extensive use of graphic calculators (TI-48 and TI-82), and a range of materials and texts that addressed mathematics as an integrated body of knowledge.

Outside Influences on Reform. At Fruitvale High School much of the professional development occurred in the form of informal networks that formed as a result of the faculty's extensive travel to national conferences out of the district and out of the state. This travel was funded by grants and award money. Travel to conferences influenced and inspired the teachers to try new things. The relationships that they fostered at these national meetings acted as support for sustaining the changes at Fruitvale High.

Outside learning opportunities were important to members of this math department. Teachers often referred to the number of times they had made presentations at conferences or attended teacher development workshops. Teachers enjoyed collaboration and interaction with other teachers in and out of their department, and the network of support that they developed outside of the school was crucial to their continued emphasis on trying new ideas in the classroom.

One teacher, Mrs. Harris, spoke about the inspiration she received from going to other places involved in change:

> I've been fortunate enough to be able to go to some different places where they're really involved in change, in making change. And so what happens with that is then I come back and I feel the need to change for our students. We have a unique department. There are a lot of people that are really open to change. We have very few people that are not really open to change. And most of our people are interested in going to conferences and workshops and have really been involved in their summers in different types of programs. And that as a whole has helped move us along. Whether it's just in applied math or the math-science class or the North Carolina materials, whatever we're doing it's because people have gone out.

Upon return from an Applied Math conference, two teachers remarked: "It was like being at an AA [Alcoholics Anonymous] meeting. Everyone was saying 'My name is so-and-so and I teach applied math. More beneficial than the classes was talking with the other teachers. We all had war stories to tell."

Mr. Wolfe remarked that the network of people that he had met while at a national conference and during subsequent follow-up conferences became his support group. Mr. Davis also spoke of a strong involvement with the people he met at national conferences, institutes and training sessions, as well as with a group of writers with whom he worked during the summer months on an applications-based mathematics curriculum.

Teachers attended conferences and workshops because it was encouraged as a part of membership in this department. Funding came from a variety of sources, including the local teacher's union which bargained with the district for inservice dollars that funded the substitute teachers the math department relied on to go to conferences and workshops during the school year. The District received vocational education funds allotted by the state and teachers of Applied Math used these funds to go to conferences. Award-winning teachers used part of their prize money to assist other teachers to go to conferences. Several teachers stated that in one way or another, "you can always find money to go out to teacher conferences."

The importance of subject area teacher collaborations have been described by Lieberman and McGlaughlin (1992). These authors describe the networks that teachers participate in, which they contrast with inservice training formats, as more closely aligned with the needs of individual teachers. They state that, "Teachers choose to become active in collegial networks because they afford occasion for professional development and colleagueship and rewards participants with a renewed sense of purpose and efficacy." Along with the sense of renewal, the teachers at Fruitvale gained a deepening of content knowledge as well as the social benefits of feelings of inclusion in a professional community.

Membership in this national community influenced curricular aspects of the department, but less so pedagogical aspects. The link between what teachers learned when they traveled to conferences and the improvement of practices beyond the textbook was not readily apparent. Returning from a three day conference on the use of North Carolina pre-calculus materials, two teachers decided to use one of the techniques they had read about at the conference. The following vignette describes that incident:

Vignette

> *Mr. Cook and Ms. Harris had been in North Carolina at the Lead Teacher Development Project for a three day workshop. On their return, they decided to use one of the techniques that they had read about at the conference. Their Pre-calculus students had recently had a quiz, and the two teachers told their students that while the problems that had been answered incorrectly had been marked, the correct answers were not on their papers. The students were going to be allowed to correct their quizzes and receive a higher grade. What they needed to do was explain in writing what they had done wrong, and then fix it. "Our goal is that you prove you know how to solve these problems," said Mr. Cook. The students became visibly excited and began talking all at once.*
>
> *What are the total points possible?*
> *We can re-do it?*
> *We can raise our score? Cool!*
> *Is it open book?*

Mr. Cook stated that they could use any source they wanted to fix their exams. The students were incredulous: "Wow!"

Mr. Cook then asked, "Do you want the right answers? I've got the answer sheet. Do you want the right answers, since what we care about is how you got there?" The students agreed that they did not want the right answers, and working in groups of three and four they began correcting their quizzes. Mr. Cook was stunned at their reaction. The kids were excited and a buzz of talk about math problems took over the room:

Student one:	*I still don't understand what I did wrong.*
Student two:	*Let's see. All you have to do is write it as a logarithm base four.*
Student one:	*I know. I screwed up. Now what do I do? Write what I did wrong and how to fix it?*
Interviewer:	*Why didn't you want the right answers when your teacher offered them to you?*
Student two:	*Because it's more challenging to rework the problem.*
Student one:	*The right answer won't help me to explain the steps it took to get there.*

The time flew by and the students remained actively engaged in their process for the entire fifty minute class. When Mr. Cook announced that it was time to go, a student stood up and said, "Are we going to do this tomorrow? There are some students with major problems". Mr. Cook responded that indeed they could continue on this tomorrow, and the students were relieved.

. . .

Discussion. These upper level pre-calculus students were using the North Carolina materials that require critical and independent thinking. This exercise excited a spark among the students that was not always seen in the math classes at Fruitvale High School. Ms. Harris, who had also attempted this strategy in her Pre-calculus class, reported a similar incident. When asked if they would try this practice again, both teachers responded that they didn't know. They hadn't thought about it in that way. Maybe, they said.

What worked against further incorporation of new ideas that these teachers brought from their outside sources? In discussing the incident with Mr. Cook, he voiced concern that the students would begin to slack off when studying for their quiz, if they knew that they would have a chance to correct it later on. This assessment practice, he believed, would undermine the academic integrity of his students. When pressed to reflect on the evident engagement of the students in their own learning process, the teacher stated, "How are we supposed to figure out these things, and still teach 150 students a day?" He had attempted a new practice and been successful, but was overwhelmed by the idea of integrating it into his daily routine.

The improvement of pedagogical practices is time-consuming, challenging, and sometimes disruptive. These high school teachers were apt to shrug off pedagogical change in favor of the less time consuming and perhaps more interesting (to them) curricular change. This practice was reinforced by participation in extraschool communities of mathematics educators who were content area specialists, not experts in pedagogical reform.

Administrative Influences on Reform. Teachers interviewed spoke of the unconditional support they received from the district and school administration during the late 1980's when all the curricular changes described above were being implemented. In particular, they referred to a principal who abruptly retired at mid-semester of the 1992-93 school year and a Curriculum and Instruction administrator who died in 1991.

This principal approved of and deeply trusted the changes that the key players in the math department initiated. When Wolfe refers to the climate in the late 1980's he says, "The principal trusted us and his philosophy was that administrators don't have all of the answers. He let us figure out the answers; he treated us like specialists, like we knew the content well enough to know where to go with it. He didn't let test scores drive things, and they shouldn't. We didn't have to do a selling job to parents either. The administration covered that for us." Davis describes this principal as someone who gave decision making power to the math teachers. Others refer with sadness to the time that the principal left as a time that the support for changes stopped. "When we lost our principal, things stopped happening for us," said Davis.

Several of the teachers referred to the Curriculum and Instruction Director as another administrator who gave them freedom to make their own decisions. Much of this freedom came in the form of money. The Curriculum and Instruction administrator was described as "tapped in to the money line." She was able to find money for the teachers to attend conferences and purchase materials. She and the principal both were creative in their budget making, so that dollars could be "found" when needed by members of the math department.

People talk about the loss of these two individuals as a turning point in the process of reform at Fruitvale. The climate for innovation had changed, they said. The current principal, who was retiring at the end of 1994, was regarded as a keeper of the order, but not a forward thinker or reformist; and the changing district personnel were no longer seen as allies, but as impediments to the reform.

II. THE REFORM CURRICULUM IN PRACTICE

The Implementation of Materials and Courses

The influences described in the previous section led to the implementation of a series of new materials and courses aimed at involving students more deeply in mathematics. The list of new materials and courses included:

- the North Carolina materials
- the University of Chicago School Math Program materials
- the Integrated Science-Math Course
- the Introduction to College Math Course
- the Tech Prep materials

These materials and the courses in which they were used are described below.

North Carolina materials. The North Carolina materials are unique in their use of technology to solve problems and enhance students' understanding of mathematics. The materials are described as providing a foundation for future work in mathematics; more specifically, calculus, finite math, discrete math and statistics (Barrett et al, 1991). The text is application-oriented and presents mathematics in investigative problems located in the context of real world applications. Six themes are used in the book:

- mathematical modeling
- computers and calculators as tools
- applications of functions
- data analysis
- discrete phenomena
- numerical algorithms

The North Carolina materials were used in the pre-calculus class offered to juniors and in the newly designed "Introduction to College Math," a course for juniors and seniors that replaced a course entitled "Mathematical Analysis." "Introduction to College Math" used the North Carolina materials as well as *For All Practical Purposes* (Steen, 1988). *For All Practical Purposes* was designed for a survey course in mathematical ideas with emphasis placed on real world applications of mathematical knowledge. The contents included:

- management science
- statistics
- social choice
- size and shape
- computers

The subjects in these materials were re-ordered and content was presented in a contextual fashion. These materials, thus, promoted a substantial change in the mathematics teaching.

The University of Chicago School Math Program. The UCSMP materials represented a different and non-traditional approach to the teaching of mathematics, as was called for in the NCTM Standards. The incorporation of reading as well as the integration of subdisciplines such as algebra and geometry within the text led many teachers towards a new orientation in mathematics education. "The material is re-ordered in a very non-traditional way," said Mr. Davis. "It requires a different approach to mathematics."

The text itself involves a different approach to the teaching and learning of mathematics by incorporating more reading as well as integration of the subdisciplines of math. The topics are re-ordered in comparison with traditional texts of the time, which tended to have topics at the end of the book following a large series of computational exercises. Many teachers in the district rested their reform efforts on the adoption and use of this text.

For other teachers in the district, particularly middle school teachers, the new text books were so fundamentally different that they felt uncomfortable. They found the ordering of the content threatening. Instead, they rejected them and stayed with traditional text books and traditional ways of teaching.

Others, like Mr. Wolfe, wanted more knowledge of the new ideas about mathematics that were cropping up then:

> I had a geology degree. I wasn't a mathematician. I learned on the fly, and by attending conferences. I've always been open to new ideas. I'm not hung up on whether something works or not, I'm willing to try and try again.

In 1993, when all the UCSMP materials were in place, students took a series of courses that began with Algebra in 8th grade, then went on to Geometry in the 9th grade and Algebra 2 in the 10th grade. At this point students who passed the math competency test could opt out of further math classes. Students could also go on to the North Carolina materials and take pre-Calculus in the 11th grade and Calculus in the 12th grade, or take Introduction to College Math or Functions, Statistics and Trigonometry as a junior or senior. Some students did not begin the UCSMP sequence until 9th grade, depending upon the recommendations made by the previous middle school math teachers.

The Integrated Science-Math course. As described above, the practice of mathematics at Fruitvale High School is so embedded in text books that restructuring a classroom or learning experience around something other than a text is a radical thought. One of the most innovative practices at Fruitvale High did just that. It was an integrated Science-Math course offered to juniors and seniors and took place both off and on campus. The course implemented new theories in mathematics education. When off campus, the students gathered data towards a comprehensive study of a natural site. When on campus, students studied freshwater biology as well as data analysis, statistics and trigonometry using the North Carolina materials.

The Integrated Science and Math course was designed by a math and a science teacher who teamed up to apply for district funds earmarked for innovative programs. In the first year, 1991, the course was funded by the district. In the second year, the course was funded by the high school budget, and in the third year the course was funded by a $12,000 grant from GTE Telephone Operations that provides moneys to teachers through a program called Growth Initiatives for Teachers.

Applied Math. While the district's lower scoring students received special funds for remediation and the top scoring students had a variety of course offerings in mathematics-- such as Introduction to College Math, the Integrated Science-Math course, Functions, Statistics and Trigonometry; Pre-calculus; and Calculus--the middle group of students who were in the non-college bound track had no specific funds for curricular offerings or training to prepare them for the work force. Businesses and the State Department of Education teamed up to provide grant money to educators to develop new materials that utilized the teaching of mathematical problems in applied settings for this group of students. Locally, the community college expressed interest in recruiting students into their Associate of Technology degree program. This was the beginning of a conversation between the college and the school district regarding an applied math program. Additionally, the math department at Fruitvale High School began looking for an alternative to the UCSMP track for students who were unsuccessful in this series.

Large businesses set up funds for a new approach to vocational education that would integrate mathematics, business education, science, and technology. Math teachers were eligible for these funds only if they became certified in vocational education. Special one-week workshops enabled mathematics teachers to attain vocational certification, much to the chagrin of vocational educators who had spent an entire year getting certified.

One course created from the money available for developing curricula in vocational education was Tech Prep. Instituted in 1991, Tech Prep was described as applied coursework in communications, biology, and mathematics. Any teacher certified in vocational education was encouraged and received funding to attend Tech Prep workshops. In addition, large sums of money were available for these teachers to purchase "hardware" for their classrooms. Teachers at Fruitvale who took advantage of this program had TI-82 graphic calculators, televisions, VCRs, storage cabinets, new tables and chairs for students, and padded, high-backed chairs for themselves, unlike teachers who had not gone through the certification process and applied for these funds.

Summary of Current Materials and Courses and Who Uses Them. The strands of materials and the courses in place during the 1993-94 school year were:

MATERIALS	COURSES	GRADE LEVELS
North Carolina School of Science and Mathematics	Pre-calculus	11,12
	Introduction to College Math	11,12
	Integrated Science-Math	10,11,12
University of Chicago School Math Project	Integrated Algebra	9,10,11
	Modified Algebra	9,10,11
	Integrated Advanced Algebra	9,10,11
	Modified Advanced Algebra	9,10,11
	Integrated Geometry	9,10,11
	Functions, Statistics, Trigonometry	10,11,12
	ESL Math	9,10
Applied Mathematics	Applied Math	10,11,12
Consortium for Mathematics and Its Applications (COMAP)	Introduction to College Math	11,12
Tom Dick's Calculus and Thomas and Finney, *Elements of Calculus*	AP Calculus	12

The Fruitvale High School mathematics department had in place materials and technology that they considered cutting edge in high school mathematics. Materials were applications-based with an emphasis on a range of mathematical concepts and procedures. Graphic calculators were in the hands of most math students, and the staff used the computer lab as a teaching tool. These materials and technology were important tools of the community that allowed a sophisticated approach to the teaching and learning of mathematics.

The technology and materials in place at Fruitvale were costly. The staff was creative in their search for funding sources for the hardware and software that they possessed and administrators were helpful in finding dollars earmarked for reformed practices. This joint effort was rewarded with purchases that ranged from plane tickets and conference fees to tables, chairs, and computers, all of which benefited students and staff alike.

Goals for Student Learning

Although new reform-oriented materials and curricula were implemented at Fruitvale, there was on-going debate over the goals for student learning that curriculum should target, as well as the appropriate content for students to learn.

The goals for student learning at Fruitvale High were reflected in statements teachers made about mathematics. If mathematics was seen as a set of isolated skills, then the goal for student learning was the acquisition of these skills. However, most of the teachers viewed math as a system, as a whole, and as a way to approach problem solving. As a result, the goals for student learning were for students to think, to build knowledge, and to be effective citizens. Materials chosen by teachers reflected these sentiments about math education.

A conflict around these goals seemed to stem from the unanswered question: How much and what type of basic content knowledge must a student have? Most teachers were keenly aware of the standardized tests which students had to be prepared to take as college bound seniors and in the upper level classes there was a reluctance to turn the agenda over to conceptual understanding entirely. Teachers made comments such as, "Things that bring us back are that we have a product to put out that has to do well on the SAT. Kids have to be prepared for college." One of the more traditional teachers, Mr. Turlington, talked about the conflict between the goals for student learning and the beliefs that keep the goals from coming to fruition:

> There is a pull between traditional math and math where you're teaching what you think kids should have for the real world. It's fun to solve problems, but there's really no use for it in the real world. The UCSMP materials don't have enough grounding in the basics. If you do too much experimentation, the kids will miss what they need to go on.

Mr. Davis, though, was perfectly willing to engage in problem-solving in his classes. He saw the world as full of problems that could be solved mathematically, and hoped to impart that to students, as well as the skills that they needed to solve these problems. In the vignette below, Mr. Davis and a student in one of his Advanced Algebra classes depict their beliefs about problem solving:

Vignette

The students in Mr. Davis' class have been given back a quiz and are asking questions about their answers. The quiz consists of one problem that they have to solve in teams of three. The problem is: A farmer has chickens and pigs that total 60 eyes and 86 feet. Find how many of these animals are chickens and how many are pigs.

The students offer their strategies to Mr. Davis as he acts as a scribe for them, writing their suggestions on the board. A student asks how the solution, which assumes that all of the animals have even numbers of eyes and legs, takes mutant animals into account.

> *Mr. Davis: If we take a real world problem and convert it to mathematics, we make some assumptions. It's important to know different methods to solve problems. You have shown that we could use matrices, substitutions or linear equations.*
>
> *Student: What's the point of knowing different ways, when one way is the easiest?*
>
> *Mr. Davis: Because problems vary. We learn these because as problems get more complex, we want to be able to solve them. Don't forget, the critical part is figuring out your method of solution.*

. . .

Discussion. Mr. Davis has different goals for student learning than Mr. Turlington, yet they both use the same materials and teach the same types of students. Mr. Davis saw mathematics as a way of thinking and a way of seeing the world which he believed was important for life-long learning. Mr. Turlington, on the other hand, had a different picture of the purpose of mathematics and the goals for student learning, one that was more steeped in rote knowledge. This pull between beliefs about the place of computational expertise and conceptual understanding in a presumed hierarchy of mathematical knowledge reappeared at this site in curriculum, assessment, and choice of materials.

New Content

Some teachers at Fruitvale High emphasized application of knowledge, strategies to use facts, and integrated content more than others, and in these classes, conceptual understanding was central. Four of the classes at Fruitvale that offered particularly salient examples of practices that emphasize conceptual understanding were the Integrated Science-Math course, the Introduction to College Math course, and the Pre-calculus course. All of the classes were offered to juniors and seniors, although there were a few sophomores in some of the classes.

The Pre-calculus class used the North Carolina materials, while the Introduction to College Math used the North Carolina text *Contemporary Pre-calculus Through Applications* and the COMAP text *For All Practical Purposes.* Are these materials particularly conducive to conceptual emphasis? Or are the students at the upper level of their high school mathematical career, and therefore more able to apply their knowledge and process information? Perhaps the answer is both of these. The North Carolina materials are designed to use math to solve problems and elicit or introduce the math that is needed to solve problems. The materials involve the use of mathematical modeling, a technique which allows students to summarize what is going on in the real world. Students can then play with the math through the models to apply what they have learned to different situations.

Seemingly, the design of these courses was aimed at conceptual emphasis and the use of context to apply concepts. The Introduction to College Math class, as with all of the upper level courses, placed emphasis on the use of technology in the form of computer software and graphic calculators. In addition, it combined multiple perspectives of math in an effort to prepare students for "effective citizenship." The course, as described in the High School Course Guide, 1993-94, covered geometric probability, data analysis, function analysis, calculus, algorithms, decision making, matrix algebra and applications, modeling, probability and statistics, graph theory and appropriate uses of technology.

The students in Introduction to College Math worked on several projects throughout the year in which they applied mathematical concepts to problems. One such project involved the discovery of the relationship between the length of the arm bone (radius to ulna) to the length of the leg bone (tibia). Students worked in teams and related their findings to paleontologists' findings regarding "Lucy," an early hominid. The question they sought to answer was: How would the information you have learned help you to determine height if you found a radius, a tibia, and a skull? The presentation of this project by each team to the entire class illustrated elaborate use of technical vocabulary as well as an understanding of the procedures.

Other real world problems addressed in the Introduction to College Math included the configuration of street routing based on Euler circuits, prediction of voting outcomes based on different mathematical theories, and the exploration of codes such as the binary code, which is used in programming computers.

New Teacher Roles

Key to the reform of mathematics curricula is the shift in the teacher's role from locus of authority and transmitter of knowledge to that of problem poser and manager of the ensuing discussion, with an explicit deflection of the role of teacher as keeper of the knowledge (Anderson et al, 1994; Romagnano, 1994). This new role assumes an ability on the part of the teacher to establish norms of discourse (NCTM, 1991) while engaging the students in a verbal and mental exploration of a mathematical problem. Richards (In Von Glaserfeld, 1991) describes the nature of traditional classroom discourse as an information transfer in which the subject is presented as a collection of facts. In this traditional setting, because the teacher controls the classroom dynamics, a true mathematical discussion which involves a creative series of spontaneous responses does not occur. The re-negotiation of norms of discourse to allow for spontaneity, inquiry and discussion was difficult for teachers and students at this site. Romagnano (1994) characterizes one student response to this re-negotiation as disengagement. In his analysis, the curricular changes called for in the reform of mathematics "substantially changed both the nature and the amount of expectations placed on our students" (Romagnano, 1994:63), resulting in disengagement or resistance on the part of the students. The negotiation around the changing nature of the teacher-student relationship in the classroom is described in the following vignette.

Vignette

> *Students file in to their Algebra class and take their places at one of the nine tables which are arranged around the large, sunny classroom. The walls are bare except for a string of pictures showing men and women mathematicians throughout history.*
>
> *A girl walks in, Sandra, and says to no one in particular but in hearing range of Mr. Davis, "It's the worst day of my life." "You always say that," responds Mr. Davis. "No I don't! I've never said that before", she replies testily. "It's only nine o'clock in the morning. How can it already be the worst day of your life?" Davis asks. "Last night my sister's dog ate my curling iron, so I look like crap. And I'm not speaking to half my friends. Well, two of them." "You only have four friends?" Davis is teasing her, as he often does with the students, who seem to enjoy these exchanges with their teacher. Sandra finishes the conversation saying "It's really bad, O.K.?"*
>
> *"O.K. people, listen up." This time Davis is speaking to the entire class: "You only have five days to finish up the chapter. You're going to someone else's class next term, so we have to get you through chapter four by next Tuesday. [They had spent three weeks outside of the text working with codes.] I've prepared a summary for you."*
>
> *Most of the students in this Algebra class are sophomores. The trimester is about to come to an end and they will continue in Algebra, but with a different teacher. Mr. Davis takes a seat at his desk while the kids settle in, get out their books and begin to work. They talk quietly among themselves. Some read books from other classes, one girl reads Glamour magazine with a defiant look on her face, but most are working in their math books. Every once in a while someone raises a hand and asks for help. Mr. Davis walks around the class talking quietly with students, checking up on their progress.*

Suddenly a student challenges Davis as he walks by her table. "Why don't you teach us?" It is Sandra. "It's not my responsibility to just sit here and look at this stupid book. You should be teaching us."

Davis replies, "It's not my responsibility to learn the material. It's your responsibility to learn the material."

Sandra implores him, "But why don't you lecture us? We need you to lecture us."

"I'll lecture you privately right here any time you ask me to. But I'm not going to stand at the chalk board and lecture you. That's not how kids learn best," Davis answers.

Sandra is not finished. "Yes it is. That is what a teacher is supposed to do. Every teacher stands up and gives a lecture but you."

Another student, Maria, chimes in. "We just do it all by ourselves and there's no help. You say we don't listen anyway when you lecture, but this way is too boring. I don't think I should have to ask for help. You should be able to tell us exactly what we're doing and how to do it."

A third student, Brad, says "You don't make us do anything. We need somebody to push us. And if you don't, I don't do it."

The girl who was reading Glamour magazine adds, "We need a teacher who'll say, 'If you don't get this done by tomorrow, then you'll get a zero. And if you get zeroes for the whole trimester, you'll fail.' "

. . .

Discussion. Mr. Davis is used to these attacks on his teaching style. He describes it as a function of age. "They haven't figured out that they're responsible for their own learning yet." Or he blames himself, saying, "I'm not the best teacher. The others are better teachers than I am." The other teachers do lecture more. In the typical class at Fruitvale High, the teacher lectures for twenty-five minutes and then the students work or talk with each other for the remaining twenty-five minutes.

The students are clearly frustrated by the passive role taken by Davis, but his beliefs about the teacher's role in this learning have led him to this practice. He believes that lecturing should not be used often because the students rely on the teacher as keeper of the knowledge, and are unable to see themselves as discoverers of the knowledge.

The UCSMP materials require more reading and subsequent analysis of integrated, contextual problems than most algebra texts. Mr. Davis believes that a thorough reading of the text would lead to inquiry and discovery on the part of the student, in effect raising the expectations for students to think about mathematics in complex ways and to be responsible for their own learning. However in his process of removing himself from the classroom as lecturer, he has not set up an alternative structure. Instead, in the student's mind he had disappeared, resulting in their disengagement and resistance. The NCTM Professional Standards for Teaching Mathematics (1991) describe the teacher's role as one who orchestrates the discourse in ways that contribute to mathematical understanding. At Fruitvale High School, more attention was paid to acquiring cutting edge mathematics materials, than to the changing role of the teacher and of the student. However, informal re-negotiation of these roles was ongoing.

Teacher Role and Student Role in the Integrated Math-Science Class

A course that offered a different construction of teacher role and student role was the Integrated Math-Science class. This course did not rely on text or materials. Instead it relied heavily on relationships between people and created a context for students to be initiators of their own learning. The class met daily for two hours. The prerequisites for this class were Biology and Advanced Algebra, and students were hand selected by Mr. Cook and Mr. Harmon. The two teachers looked for students who were self-motivated, and also aimed for an even combination of juniors, seniors, males and females. The students worked in teams of four which were self-selected. In years past the teams were designed by the teachers. "We wanted to have one strong student on each team, and so we selected the groups, but self-selection has worked just as well," commented Mr. Cook. These teams were formal cooperative groups, as opposed to the informal groups that work together as a function of the table arrangements in the other classrooms. The two teachers of this class saw enrollment in this class as a serious commitment to the group. The kids had an obligation to their group, to the whole class, to GTE (the grant sponsors) and to the teachers. Mr. Cook and Mr. Harmon easily articulated the differences between their role in the Integrated Science-Math class and their role in their other classes. Mr. Harmon described the cooperative group:

> Kids in this class are expected to work cooperatively. They don't have the option of joining another group if they don't get along in their group. They have to work it out. It's a formal group. There's always going to be some rubbing, otherwise they're not working close enough. We verbalize to them what their strengths are. We describe the roles within the group to them.

The goals of this class were easily understood by the students, who worked together for the entire year as they developed a major report which would be a source of information for a local conservation group. Several times a week, depending on the weather, students traveled by van to a shallow canyon which encompassed a creek and a hiking trail along side the creek. Each team was responsible for a section of the creek. They collected data, analyzed it, and created a topographic map of the area to answer the research question: Is the stream healthy? The following vignette describes a day on site with the teams and their teachers.

Vignette

The two vans headed away from the school, loaded with gear and kids. The kids are upbeat and excited to be out of the building. They talk and laugh and gently tease each other. They really seem to enjoy going out into the field. The teacher drives west for about 20 minutes to Shale Canyon. An abandoned rail road bed is now a path through the canyon, and the old trestles are foot bridges over the creek. Everyone gets into one van at the trail head. The Shale Creek Preservation Society has given the school permission to drive on the trail. The first stop is at a locked gate. One of the kids gets out and unlocks the gate.

They drive to Bridge One and the first team gets out of the van. They will collect water samples which they will test for silica, oxygen, the pH of the stream and other chemical analysis. They know exactly where they want to get out and Mr. Cook asks them to direct him to the right spot. These kids will be on their own for about 45 minutes as they conduct their tests. The other teams get out of the van at about 1/2 mile intervals. Each team has a section of the creek and the canyon they will test and map out.

The last team to the end of the trail has an electronic transit and a battery to hook it up to. A friend of Mr. Cook's has donated this equipment to the class. It is worth about $13,000 and offers a very precise measurement of angle, slope, and vertical and horizontal distance to assist the kids in mapping the canyon.

There are four students on this team; one girl and three boys. The girl, named Robin, seems to be running the show in a very unassuming way. Two of the boys on this team were the focus of much ribbing for their habitual tardiness and absences. It was common knowledge that they both preferred to sleep rather than come to school. They are the ones who must scramble about the shale walls of the canyon to place the prism which is the target at which the transit is aimed. Robin directs their position on the cliffs while her partner, Don, reads the transit. He asks Robin to check his readings, and she in turn asks Mr. Cook to check her readings of Don's readings. Mr. Cook constantly asks questions about the choices the kids are making in their placement of the prism, the reading of the transit, and their sketching of the site. His questioning is not challenging of their positions, rather it elicits thought and consideration from the students.

"Is that a good spot for the prism?" Robin asks. Mr. Cook replies, "Well, let's think about it. Where was your last reading?" Robin points to the spot on the cliff that they last took a reading from. "And where do you want to go from here?" She points again. "OK, does that spot make sense?" he asks with a straight and unreadable face.

"I think so," says Robin hesitatingly. While Mr. Cook routinely asks procedural and conceptual questions of the kids, the kids are often hesitant in their answers. An interview with Robin reveals her thought processes:

> *My other math classes, you're in a classroom, you have a book, and the teacher tells you what you're doing. You do this step, that step, that step and you get an answer, so it's simpler that way. This way the teacher is trying to make me come up with an answer on my own. They're asking you to think on your own to get the right answers. And then if you make the wrong decision, you have to kind of learn on your own. So that's good, but it's tough that way.*

Suddenly Don spots a squirrel on the side of the canyon wall and runs to the van to get the camera. They are documenting all wild life in the canyon. They have seen a blue heron, coyotes, rattlesnakes, garter snakes, and rabbits, as well as a variety of birds.

The boys on the cliff have a hand-held radio to communicate with their teammates at the bottom of the canyon. They laugh and tease each other as they do their work. It's a cold, cloudy day. We all shiver and talk as we wait for the cliff scramblers to hike to their next location. Back down the trail, Team 3 is working. It's a soft, narrow trail cut through rocky cliffs. Most of the trail parallels the creek, but some of it winds back and forth across the creek and over trestles. No one has seen the blue heron in months. Suddenly it flies up into the sky, a huge silent bird, startled by the presence of busy students in the quiet afternoon.

The van comes along to pick up Team 3. Everyone seems to sink exhaustedly into their seats, wrapped in the heat of the motor. As the van drives along the trail, picking up the other teams, the students begin to talk:

> *"Hey, did anybody else get a really low oxygen reading, or was it just me?" a student asks.*
>
> *"What's low?" another replies. "Compared to what?"*
>
> *"My reading today was 3. Last time it was 8 or 15 or something."*
>
> *"No," a team member corrects. "It was 7.5."*
>
> *"Well, is 3 low?" the student asks.*

Mr. Cook asks him if he re-ran it. "Are you sure that's your reading?" he presses. They all discuss oxygen readings for awhile, and kids offer ideas about why the reading might be low. Mr. Cook listens, but doesn't give an answer until they run out of ideas about why it might be low. Finally he remarks that 3 is really low. "I know there's more than three parts oxygen per million in that *stream or the fish would be belly-up. When you get that kind of reading, it just has to be redone," he concludes, and the conversation moves on.*

Mr. Cook heads out of the canyon to the spot where we left the second van. The students talk and laugh with each other and their teachers. When the van arrives back at school, the day is finished and the students quickly disperse. The teachers begin to talk about this class:

> *The most important part of this class is the process. We have to hold ourselves back to not tell the kids the 'answer.' We try to help the kids see themselves as inquirers, not as grade mongers. We're here to learn about learning. But getting kids to think is extremely difficult, and stopping ourselves from stifling that thinking is just as hard. Last year we had some kids that wanted to get an aerial photo of the site. They realized that it would help with the mapping, but they kept it a secret from us because they thought of it as cheating. So one of the kids went up in his dad's airplane and got an aerial photo. I see that as using their brains, they see it as cheating.*

. . .

Discussion. The teachers in this integrated course had a conscious agenda that involved team work, discovery learning, and the use of content as it was embedded in context. They were confident that the amount of science and math that the kids learned would be high, and they were willing to take on a different role to achieve that. Mr. Cook commented on his role as a teacher:

> Teachers are story tellers, and I love to tell the story. But now I think it's better not to tell the story, to let kids figure out what the story is on their own. My experiences in the integrated class have leaked into my other classes. I question more, don't give as many answers. But it's a different course, a different philosophy. I'm looser as a teacher now. It's much easier to be structured, but I don't think the kids learn that way.

Thus, membership in the integrated mathematics-science course allowed for a different set of roles and relationships to emerge. The non-traditional setting (the stream site), the non-traditional format (cooperative teams), and the non-traditional curriculum (integration of mathematics and science) became fertile ground for the re-negotiation of roles and a shift in the locus of authority.

In the algebra class described in the preceding vignette, the only clues that the students had that the format was different was that the teacher no longer lectured to them, they sat at tables in groups of four or five instead of at individual desks, and the mathematical topics were embedded in their text books. These clues did not give the students enough direction to allow new roles to be taken on, or to allow for a shift in the locus of authority. This teacher knew what he didn't want his math class to look like, but could not easily translate that into what he did want his math class to look like. There was little clarity of intention communicated to the students about the changes that were being made in their behalf and the expectations that were placed on them as a result of those changes. When these intentions were more clearly articulated, as in the Integrated Science-Math class, the behaviors were more easily negotiated, the roles more easily taken on.

Issues of Assessment

Assessment differed from teacher to teacher and from course to course at Fruitvale High School. Some teachers used unit and chapter examinations as their only form of assessment; others saw assessment as an ongoing process and utilized a variety of methods to assess students' skills and knowledge.

The Integrated Math-Science class used the final team reports and the data analysis for assessment. Mr. Cook evaluated the quality of team work, as well as the motivation and cooperation of individuals. The team members evaluated each other in a confidential questionnaire which assessed individual cooperation and leadership. In addition, they also used ongoing assessments such as quizzes, tests, and rough drafts of the final report. In the spring, students wrote resumes and responded to fictional job openings in areas that demanded similar knowledge to the expertise that they were developing in the field. They described the knowledge that they had learned in the course, and explained how it was relevant to the fictional job opening.

Mr. Cook appreciated the authenticity of the team report as a means of assessment, but felt constrained by time to develop alternative assessments for all of his classes, the way that he and his partner, Mr. Harmon, had for the Integrated-Science Math Class. "We think and talk about portfolio assessment in the department, but we don't have the time to develop what that is."

Ultimately, teachers felt the SAT hanging over their head as a measurement on which their students had to be successful. The average mean SAT math scores at Fruitvale since 1988 were:

	Fruitvale High School	State Score	National Score
1988	527	494	476
1989	515	491	476
1990	510	486	476
1991	466	480	476
1992	470	484	476
1993	494	486	476

Teachers at Fruitvale considered the decline in test scores over the years reported above to be statistically insignificant since they hovered close to the 50th percentile each year. Some of the teachers believed that there had been a de-emphasis on standardized testing at Fruitvale, and a growing emphasis on conceptual understanding and mathematical thinking, which may not be tested by the SAT, and resulted in lower test scores. The drastic change in student demographics over this period of time should be noted also.

III. THE CONTEXT OF CHANGE

The process of change was ongoing at Fruitvale High School. As the force and intent came from within the staff of the mathematics department, the culture of that department was an important aspect of the reform process. The culture of the department was one of continual learning and investigation into the content of mathematics. Yet the culture of the department also placed primary emphasis on new materials and technology, often at the expense of considerations of pedagogy. And the new materials and technology were, for the most part, implemented in college-bound courses, which meant that Anglo students were the primary beneficiaries of the reform efforts. Finally, perceptions of community expectations being counter to reform efforts served to impede the teachers' forward-looking efforts. Each of these issues acted as either an enabling factor or a disabling factor in continuing the reform process that began over 10 years ago at Fruitvale High School

The lack of consensus among teachers regarding their beliefs about the purpose of mathematical knowledge and the pedagogical strategies needed to teach was a disabling factor.

Some teachers mentioned curriculum reform with a concern over their obligation to make sure that students were getting the basics. Sharon McCarthy spoke about reformed curriculum that she combines with "skill drills" in her class for lower skilled students:

> The new stuff that is coming in is more an applied basis, it's not traditional, out of the book stuff. I see math going that way all over. I think it will connect more kids, and I think the one thing we need to be careful of is you still have to have mastery of something somewhere. You can't let them roll along without making sure that they don't have the basics because eventually they'll be rolling along with no comprehension. I think we need to be real-careful as we're doing this reform that we are still looking for basic skills somewhere. In my Applied Math, we do problems and activities where they actually set up and solve the problems, but if they haven't got the manipulation skills for solving an unknown, then they're really hurting. And so skill drills help us with that piece. But the goal in using projects and experiments is to get kids to think and write mathematically. That's the hardest part.

Another teacher, Kathleen Harris, spoke about the need for a certain amount of skill knowledge:

> Ms. Harris: I think the North Carolina materials are going in the right direction and the Interdisciplinary Math-Science class going in the right direction.
>
> Interviewer: Do you think that all of the math that those students need to get to that point [the integrated class] should be taught before hand, or can they get the math they need in that class?
>
> Ms. Harris: They're going to have to have some mathematical skills, at least a starting point. But I think that a lot of the math they can learn as they go along, as the need develops. But how much needs to be taught before that point, is a good question.

Ms. Harris echoed Ms. McCarthy's concern that "at least a starting point" of basic skills would have to be learned before students could join an interdisciplinary class. This contrasted with Mr.

Davis who felt that math could be taught in context from the beginning of high school, and that mathematical concepts could be taught as they came up. This is a radical notion to those math educators who see mathematics as a linear progression from arithmetic to calculus.

Mr. Davis is one of those teachers who is more willing to let go of traditional beliefs about the nature of mathematics. Mr. Davis hoped that kids came away from Fruitvale High School with a belief that math is a usable body of knowledge that is ever changing. "I want the kids, and I don't care if it's the highest ability kid or the lowest ability kid," Davis said, "to have the sense that math is a utility that's usable for them, and that's where I want to get them to."

The lack of consensus about the purpose of mathematical knowledge at Fruitvale was evident in the teachers' perspectives, and represents a piece of the reform at this site that is still in process.

The creation of a school culture that could tolerate the disequilibrium of change was an enabling factor.

The greatest enabler at Fruitvale was their culture of change. The site had been struggling with the idea of change for more than ten years and it was now built into their culture. Mr. Davis commented that he would like to see a few more changes and then leave it alone for awhile, but it's hard to imagine the department ever being at rest. Teachers come back from conferences excited and motivated to continue their work and to use the best materials and technology that was available.

Staff members were challenged by their students, particularly when the students described themselves as failures. One teacher said, "When these kids get an F, they think that means they're done. I'm here to turn that around." The energy that all of the staff put out to turn that sentiment around was both amazing and exhausting.

These educators were clearly dedicated to their students and to their field and to the hope of creating a new vision of mathematics. Their attendance at conferences reinforced the continual reshaping of the vision, as teachers engaged in discourse with experts in mathematics education. Relationships fostered at conferences provided moral support for the reform of math education nationally and locally.

Placing primary emphasis on technology and new materials over pedagogy was a disabling factor.

Departmental culture at Fruitvale posed disabling pressures to reform efforts as well. First, the culture embraced new materials and technology as evidence of change. As a result, little attention was paid to pedagogy or the role of the students as members of the mathematical community. In addition, the materials themselves included little emphasis on the changing nature of the role of the teacher required in implementing the materials.

The new materials and technology were primarily implemented in college-track courses, which tended to attract the Anglo and higher-economic students. The administration, however, denied that any type of tracking existed. This blinders-on approach to the inequalities in the distribution of knowledge in our schools is typical of members of the dominant group. The use of mathematical knowledge in our society is predominantly in high status professions (Apple, 1992). Race, class and gender have all been gates that keep certain students out of the high status professions. This trickles down into the sorting of students into the college bound group and the non-college bound group. Fruitvale High School's reputation as a college prep school kept ethnic minorities away until very recently. The changes in the demographics at the school has been drastic, yet the majority of the minorities are in lower level classes. One teacher commented, "How can they be in an upper level class? They don't speak English!" Yet out of 400 minority students, only 125 are in English as a Second Language math classes. The department's focus on the college bound students as recipients of reformed materials is an unintentional result of the reform efforts at this site.

Community expectations were seen as a disabling factor by teachers.

Another obstacle in this reform seemed to be beliefs about expectations from the community. All of the teachers mention the community as an impediment. They said things like, "We have a product to put out" or "Our clientele has changed" and "Calculus would be a very difficult course to drop in terms of the community". The changes that seemed necessary to the teachers were perceived as impossible because of the community.

What they felt limited by were the parents of college bound students for whom traditional college prep mathematics courses have worked well. These parents were concerned about their children's level of preparedness for the SAT and ACT.

IV. CONCLUSIONS AND IMPLICATIONS

As these teachers struggled with reform, they did it in isolation, within their department at a relatively large high school. They focused their attention on materials rather than on pedagogy. And they proceeded without the support of the larger school community. They perceived that they received no support or direction from the principal [who retired at the end of the 93-94 school year] and little from the district. The greatest impediment at this site was the fragmented nature of the reform efforts in the context of the district, and the lack of a cohesive, school-wide, or community-wide vision regarding the direction of the reform.

The need to establish a mathematical community.

The establishment of a mathematical community is a complex, but important link in the reform of mathematics education. As Davis, Maher, and Noddings write in "Constructivist views on the teaching and learning of mathematics," "To know mathematics requires constructive work with mathematical objects in a mathematical community." As this mathematics department evolved as a community of practice, the role of the tools in the form of technology took priority. Other activities that promoted the community were practices that allowed mathematical dialogue, such as the establishment of relationships with other mathematics educators for the purpose of conversing about mathematics.

Ted Wolfe, Howard Roseberry, and John Davis began the creation of a mathematical community. Their search for better materials allowed them to dialogue and explore and create common beliefs about mathematics. To date, this work has not focused on broader issues of school reform such as equal access to mathematical knowledge, pedagogy, and the role of the student, but on reform of math curriculum per se.

The need to resolve conflicts over beliefs about mathematical knowledge.

A conflict that continually re-emerged in this department's struggle to redefine mathematical knowledge and its application was the pull between computational and conceptual knowledge. This pull came up continually, whether in the development of curriculum, the role of assessment, the student-teacher relationship, or the choice of materials. The question was: How much rote knowledge must students possess in order to be successful in their conceptual understanding? This question appeared at every level of mathematics at Fruitvale, whether it was Calculus or "bonehead math." This question was also tied in with beliefs about kids and how they learn.

Several teachers spoke about students "wanting to be spoon fed." The belief was that the students did not want to think, and therefore, curriculum that involved too much thinking became a chore for both teachers and students. It was a chore for teachers because they had to coax their students to think. Regarding Calculus, for instance, the conflict was whether Calculus books that are too heavily weighted towards conceptual understanding actually serve the kids, who are not able to apply these skills in problem solving. One teacher explains:

> The Tom Dick text is very heavy on numerical analysis concepts. You have to assign every problem or the students can't get the concept. It's more like a college text. Our students aren't ready for that. And the North Carolina materials are made for the best and brightest in that state. Our students need to be nurtured along. There's a certain amount of technology that's appropriate for Calculus, but kids need the balance of algebraic skills with technology. They need to understand the mechanics of it, and then when they get to college they can focus on the conceptual.

In assessment, teachers were reluctant to provide alternatives to standardized tests. Referring to the episode where the students were allowed to correct their own tests as long as they could explain what they had done wrong, Mr. Cook said, "I liked what happened, but I don't want kids to get lazy. They wouldn't prepare as well if I let them do that all of the time." Mr. Cook had a belief about kids needing to get a certain amount of math into their heads, lest they become lazy. Memorization and manipulation of facts and formulas was good for some kids, and the practice of memorization through the study of formulas would prevent kids from getting lazy, according to these teachers.

These beliefs about math as something that you do to kids, as opposed to something that you think about with kids, is in contrast to the NCTM standards and to current thinking about learning. *What* students learn depends on *how* they learn it (Smith, Smith and Romberg, 1993). The NCTM standards encourage problem solving in context and discourse around mathematics, towards the development of a mathematical community.

However, there are no clear answers to the questions being raised by this faculty, such as what does a foundation in mathematical knowledge look like? What kinds of skills must kids have before they can solve problems in context? Mr. Davis believes that if teachers and curriculum writers develop interesting problems, then interesting mathematics will arise, and that is what the students will "need" to know. Other teachers remain fixated on the idea that the math that kids need to know is on the SAT and other standardized tests.

This pull is at the heart of the struggle to reform mathematics curriculum. On one side of the struggle, one hears things like: Teachers are afraid to go too far into contextualized problem solving; students don't understand why they aren't "crunching numbers" as much as they think they should be; administrators see falling SAT scores as a death blow to innovative programs; the community thinks mathematics should look the way it did when they were in school.

On the other hand, one hears teachers saying things such as: Mathematics is a way of thinking about real world problems. Students say things such as: If I can explain how I solved a problem, then I know I understand it. Administrators say things such as: There's more to our math program than SAT scores; and businesses in the community see a real value in the results of the Integrated Science-Math stream study for use as baseline information regarding pollution in the Fruitvale Valley.

Continuing the Processes of Reform

In order for the reform to go forward at this site, the discourse regarding what mathematical understanding is, and what body of knowledge kids should have when they finish high school, must continue. The teachers, students, and administrators at this site were continually renegotiating the meaning of mathematics. It is an exhausting and complex process that must involve all parties in the mathematical community. The burden is on everyone, whether they be students, teachers or administrators, to assist one another in rethinking the language, behaviors, and beliefs regarding the construction of mathematical understanding, and the roles and relationships of teachers and students. This process is ongoing as these educators strive to change the tradition of high school mathematics.

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CASE STUDY OF RIVER CITY HIGH SCHOOL PROJECT CLASSES

MAURENE D. FLORY
CURRICULUM REFORM PROJECT
UNIVERSITY OF COLORADO

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This paper was prepared for the Curriculum Reform Project, a study of curriculum change in mathematics, science and critical thinking which is funded by a grant from the U.S. Department of Education's Office of Educational Research and Improvement (OERI Grant #R91182001). The opinions expressed herein are those of the author and the participants in this study.

FOREWORD

When faced with a challenge, a detailed story of someone else's experience in a similar situation generally is of strong interest. In reading someone else's story--be it political history, a chronicle of dealing with a family tragedy, or the story of a major business success--we do not expect to find a formula to apply directly to our own situation; instead we hope to find insight and inspiration. Thus, the story contained in this report should be engaging to individuals committed to educational reform in a local school context. It is the story of one school--or department within a school--engaged in fundamental reform of education for its students.

Similarly, one should not expect to find in this case a model for a specific educational reform to initiate in another locality. Every context is different. Each local school and community culture has its distinctions, each individual's and group's educational goals have different shadings, each setting has its own history, and each school has unique constraints to making change.

Not only does one formula not fit all schools, there is no specific formula for a given school. A central message of our case studies is that educational reform is a long-term process for which there is no detailed road map. It is an uneven process with highs and lows, failures and successes, but gradual movement toward greater and more profound learning for students.

What we can expect to find in this story are insights about new teacher roles, how students go about learning with greater depth of understanding, the context in which such shifts can occur, the challenges that must be overcome to initiate these changes, and actions taken by various parties to keep the process of change moving forward. Reflecting on someone else's story can be helpful in the process of developing one's own plans, collaborating with others to move the process forward, and helping students take responsibility for learning.

The Research Project. The case study reported here is one of nine--three each in science, mathematics and higher order thinking across the disciplines--conducted as part of the Curriculum Reform Project. The cases were studies of individual schools--actually a department within a school in the case of science and mathematics--in the process of solidifying reform. Each was selected because it was a successful example of reform. A researcher spent 20 or more days at the site to learn what changes they were making, the barriers encountered, how they overcame these challenges, the nature of their successes and their hopes for the future.

Site Selection Criteria. Sites were sought which had initiated reforms consistent with those recommended by leading groups in the respective field, e.g., the Curriculum and Evaluation Standards for School Mathematics (Commission on Teaching Standards for School Mathematics). Final selections were based on program outcomes including student test scores, enrollments in subsequent elective courses in the given subject area, and professional judgments about the quality of the curriculum provided to students.

Site Selection Process. The search process began with the solicitation of nominations from researchers and knowledgeable practitioners across the U.S. Key people at the nominated schools were contacted by phone to get additional information and written exchange of information followed. Selection according to the above criteria resulted in schools spread across the country with considerable variation in location (e.g., urban vs. rural), economic level and ethnic makeup of the communities.

Research Methodology. In each case the researcher was immersed in the activities of the school and collected a wide range of information. Data included classroom observations, interviews with students, teachers and administrators, and a variety of documents from the site. The voluminous field notes and interview transcripts were analyzed and an interpretative report written.

Cross-site Analysis. A cross-site analysis of the nine cases was conducted to gain perspectives that extend across the sites. An individual case is rich in description and context but does not contain the depth of analysis that can come from looking across a number of cases. Thus, the reader is referred to the Project's cross-site analysis. Main points from this analysis to bear in mind while reading this one case, however, include the following:

- The reforms being sought are profound and demand major changes in teacher and student roles.
- The process for achieving such reforms is complex and demands a long period of time to attain.
- The schools in these cases have traveled a considerable distance on the road to reform but have not yet "arrived."

These cases are presented largely--though not exclusively--from the perspective of the teachers at the center of the cases. This perspective reflects the nature of the reforms and the way they have been initiated in each school. This perspective may be particularly important for initiating change. Our cross-site analysis shows that changes in teachers' values and beliefs--not just greater teaching skills and techniques--are central to reform. While changes in student roles and student work are the ultimate "bottom line," these teacher changes are an important intervening step.

We hope your reading of this case stimulates both interest and significant reflection about reform activities in your school.

Ronald D. Anderson
Director, Curriculum Reform Project
University of Colorado

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I. INTRODUCTION

River City High School (RCHS) is pursuing mathematics education reform under the influence of a state-wide program (the Project.) While this case is the story of RCHS, not the Project, some Project background is important to understanding the dynamics and unfolding of events at RCHS.

The Project is one of many National Science Foundation (NSF) State Systemic Initiative Programs. It is a cooperative effort of the state legislature, the NSF, the state's university system, and the state's educators to reform education at the high school level across the state. The Project is committed to developing an integrated, interdisciplinary, secondary mathematics curriculum accessible to all students and to designing teacher in-service and pre-service teacher preparation programs that will prepare teachers to teach in Project classrooms. Project literature states that successful implementation will include the use of appropriate technology (primarily calculators and computers), small groups and real-world problem situations.

In designing and implementing classroom level changes, the Project has adopted a constructivist perspective they believe is embodied in the National Council of Teachers of Mathematics' (NCTM) *Curriculum and Evaluation Standards for School Mathematics* (1989). According to a recent Project publication, moving from an instrumentalist view, a traditional view of mathematics, to a constructivist view so radically alters what it means to know and to do mathematics that it necessitates redesigning a curriculum and assessments and retraining teachers so that mathematics is represented as participation in a wide variety of activities such as question-generation, generalization, problem solving, communicating and reasoning. In addition, the Project is committed to the integration of mathematics across traditional mathematical topics and to interfacing mathematics with applications in science and other areas.

In general the changes advocated by the Project appear in two forms: changes in the curriculum (including assessment), and changes in pedagogy. Regarding pedagogy, the Project advocates a variety of instructional formats, including individual, cooperative learning groups and whole class work. It is believed that this variety will assist the teachers in meeting the needs of a diverse student body in the classroom, including students who traditionally are not successful in mathematics classes, students with learning disabilities, racial and ethnic minority students and young women.

The material used in the Project classrooms is written by a variety of people, most of whom are secondary school mathematics teachers, under the guidance of college and university professionals. Additionally, teachers and students are encouraged to report back to Project administrators about ways to improve the curriculum and aspects they particularly like. The goal of the writing is to produce a curriculum in which many of the traditional school mathematics topics of algebra, geometry, trigonometry, and calculus along with non-traditional topics such as probability and statistics are used by students, when appropriate, to solve mathematical problems which are based in applied contexts. The curriculum encompasses multiple levels and is intended to replace traditional mathematics courses at the high school level. When this case study of RCHS was conducted, the first two levels (intended to serve all freshmen and sophomores) were being used in pilot and pre-pilot test form in many of the state's high schools. The remaining levels were in varying stages of development and publication.

The experiences of the River City High School teachers and students are personal and unique and are not meant to be generalized to other teachers. The goal of this case study is to look at the classroom level actions and reactions of the teachers, students and other significant groups as River City High School participates in a comprehensive, large scale, mathematics reform effort in their quest to change the way they teach and learn mathematics.

Data Collection

The data for this case study were gathered using multiple means. Data include transcripts of in-depth, one-on-one interviews with mathematics department teachers and 20 students, and transcripts of four student groups interacting on a daily basis for two or more weeks. Extensive notes were taken during interviews with school counselors, school administrators, a district administrator, and individuals employed by the reform project. In addition, field notes were kept of classroom observations and informal conversations with students, teachers and others associated with the school or the reform. To answer the research questions of the Curriculum Reform Project an assertion analysis was performed on the data.

The Site[1]

Located in River City, a modest city by most standards but with a substantial population for this state, River City High School (RCHS) is one of two traditional public high schools in the River City School District. In accordance with the district's curriculum guidelines RCHS's teachers offer a relatively traditional curriculum to its almost 1,700 students.

In this state, students who are seeking a college preparatory diploma are required to take and pass three years of mathematics. Students seeking a general diploma are required to pass two years of mathematics. RCHS provides its students with a choice; students can meet their mathematics requirement by taking courses from either the traditional or the Project track or from both.

RCHS was chosen as a site for this study because the school's mathematics department is participating in the implementation of a mathematics education reform (the Project) that is currently being designed and implemented on a voluntary basis across the state. RCHS also offered both the opportunity to work with teachers who are among the first trained by the Project, and therefore, have the most classroom experience with the curriculum, and with teachers who have just been trained by the Project and therefore have very little experience with the curriculum.

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[1] All references to specific people (researcher excepted) and places have been given pseudonyms.

Historical Context

Reforming education is a large and difficult task. Some of the teachers and students at RCHS have been working hard to change the way they approach mathematics, and it is important to emphasize several points. First, the scenarios and the data presented here are representations of the Project at the classroom level as it has played out at only one school. Each of the other schools involved in the piloting of the Project have their own, individual stories to tell. Second, the Project, as it is reported in this document, is in its early stages of development. Already changes have been made so that the implementation of the Project at this site is somewhat different than it was when this study was being conducted. Third, the RCHS teachers and students involved in the Project at this time are working with early drafts of the curriculum.

While piloting the curriculum, RCHS Project teachers and students have noted aspects of the text that they particularly enjoyed or found helpful and they have noted where they had difficulty. Thus, the curriculum is one aspect of the Project that has undergone revision since the data for this report was gathered.

The teachers. RCHS employs almost a dozen mathematics teachers to serve its students. A majority of the mathematics teachers have been teaching upwards of ten years with some dedicating twenty plus years to the mathematics education of RCHS students. The prevailing ethos is one of caring about teaching students and teaching mathematics. In addition, an integral part of the teachers' culture is to share their time, energy and material resources as well as their enjoyment of the subject matter among themselves.

Teachers' awareness and involvement in the Project varies from intimately involved to minimally knowledgeable. Some of the teachers have known about and participated in the Project since its inception and others are still unclear as to what the Project is or what participation opportunities exist for them. Last year the three trained RCHS teachers and their students participated in the pilot testing of the initial version of the first year materials. During the second year, the year these data were gathered, there were seven trained teachers teaching approximately 290 students split almost evenly between first and second year classes. All of the teachers in the mathematics department, including those teaching Project courses, were also teaching traditional mathematics courses.

The Project offers teachers three different types of training and the training received by RCHS's participating teachers varies. Some of the teachers have participated in a continuing education course, some have been trained to assist in educating other teachers in how to teach Project courses and some have written curriculum materials for the Project. A majority of RCHS's Project teachers have participated in more than one training program or have participated in the same training program more than once. For example, one teacher participated in both the continuing education class and the training for mentoring other teachers. Another teacher participated as a writer for more than one session.

In general, the teachers at RCHS who are newest to teaching the Project curriculum have received the least amount of formal training with respect the Project. These teachers rely on RCHS teachers who have had more training and more experience with the Project for information and advice. The give-and-take relationship among the Project teachers is an extension of collegiality among the RCHS mathematics teachers in general. They share ideas about materials and lesson plans, exams and experiences. It is not uncommon for them to seek and respect each other's advice and opinions on a variety of matters regarding the Project.

The students. A majority of the students at RCHS are white and come from middle to lower-middle class families. Approximately one third of the students come from homes whose parents are employed in an occupation that requires frequent relocation. Many of the minority students' parents fall into this category. RCHS contains one of the largest number of self-identified American Indians in a non-reservation school in the state, but there are fewer than one hundred enrolled. Overall the school's minority enrollment is about six percent, a majority of whom are American Indian.

According to 1992-93 ITBS scores and student grade point averages, the students enrolled in the Project at RCHS during its first year (1992-93 academic year) were average to below average academic students. In general they did not represent the students who traditionally do well in school and in mathematics classes. This situation was in opposition to the beliefs and requests of the Project as stated in its literature. The Project encourages heterogenous classes and believes that the curriculum is capable of meeting the needs of all students, including advanced students.

The first year, the pre-pilot test year, RCHS was notified of their acceptance to teach Project classes after their students had been assigned to their classes for the coming year. Creating heterogeneously grouped Project classes would have required rescheduling the entire student body. With neither the time nor the resources to do so, RCHS converted traditional tracked mathematics classes into Project classes. Students were then given the option of transferring to a traditional class or remaining in the Project class. Most chose to remain in the Project class.

During the second year of pilot testing at RCHS, the top incoming students tended to remain in the traditional track taking mathematics courses that will lead them on to calculus and advanced trigonometry. Additionally, RCHS maintained a consistent enrollment in its lowest level traditional track course. Because these students are missing from RCHS Project classes, their voices are necessarily missing from this report.

Student perceptions of who the Project is designed to serve vary widely, but they tend to agree that whether they consider themselves strong or weak mathematics students, the Project is more appropriate for them than a traditional mathematics class.

II. THE REFORM CURRICULUM IN PRACTICE

Vignette: A Classroom Visit

The students from the previous hour have all gone and the students in the next period's class have not yet begun to arrive. The noise from the hall is typical of a high school. The classroom is bright and tidy. The walls are a deep red "school house" brick. Two of them are covered with the green chalkboards present in so many of my childhood memories. Along the third wall is a slick new white dry erase board. In the tray are a half dozen multicolored markers. The board has been wiped clean with the exception of a reminder for an upcoming special event and a short list of student names, students who have to serve detention. The fourth wall has four floor to ceiling windows. The sun is bright today so the shades have been dropped and closed to reduce the glare on the boards or perhaps on the computer screens.

Students begin to arrive, taking their places at one of the long tables. Each table is about eight feet long and has four chairs along the farthest side so that when the students take their places they are all facing forward. There is an aisle down the center of the classroom with the tables stretching outward towards the walls. At the far end of each table is a computer screen and keyboard. In the center of the room, at the front, is a teacher computer station. A computer, keyboard, and overhead projector are contained on a moveable cart that looks as though it has taken someone a significant amount of thought and time to design. The equipment is set low so that the teacher can sit in a chair and work on her computer with the computer screen projected on the screen behind her and have an unobstructed view of the students in front of her. Each piece of equipment is secure within the structure so that it will take more than an accidental bump to dislodge it.

The bell rings. The students are sitting in their groups, four to a group, eight stations, 32 students -- on a day when everyone comes to class. There is a low hum of student chatter and paper shuffling while the teacher takes attendance.

As she crosses the room to post the attendance slip, the teacher begins to focus the students' attention. For homework last night they had to read the directions for an activity that the class is going to participate in today. It is a gaming activity and each group is going to play the game, keep track of the data generated within their group, and at the end of the period, the class will pool their data. Tomorrow the class will use all of the data as the basis of a discussion and to generate some hypotheses. There is a lot for the students to do in class today, so they will have to use their time wisely.

There is a brief delay while the teacher locates some of the equipment that the students will need. This classroom is in use every period, but it currently belongs *to no teacher in particular. Several teachers rotate in and out of the room during the course of the school day; all Project classes are taught in one of two computer-equipped rooms, while regular math classes are taught in regular classrooms. The teachers seem to have worked out a system for the care and storage of the equipment, but even so, things are not always where they expect them to be.*

After the teacher clarifies the students' initial questions about what they are to do during today's class, the students rearrange their chairs so that they are facing each other and they begin to set up their games. For the remainder of the period the classroom teacher rotates through the groups interpreting the instructions and answering questions as the students work through the game. Before long and without much prompting, all of the groups are engaged in the activity. Though each group is responsible for the same type of data, they have all organized their groups differently and have their own unique ways of recording their data.

The time passes, and the period is almost over. Each group is at a different place in terms of completing the activity. The teacher is giving students instructions on how to wrap-up their games and where the equipment goes. As the bell rings students hurry to gather up their belongings and get out the door before the next teacher and group of students enters.

The Goals of the Project

Mathematics teachers at RCHS talk about the goals of the Project in basically two ways. First, the teachers talk of their understanding of the goals of the Project at the classroom level. Second, they talk about the Project with respect to its role in their mathematics department.

On the classroom level, the Project is seen by the RCHS teachers as an attempt to reach more students with mathematics and to increase the level of proficiency of those students taking mathematic courses. It is a "different approach to teaching math," "... much more like a lab course in that kids do lots of things cooperatively." The interactive teaching style, the "real world" materials, the use of technology and the integrated nature of the mathematics sets Project classes apart from traditional classes at RCHS. The teachers see these changes in classroom structure as ways to make the learning experience more interesting and perhaps make mathematics more accessible to students who traditionally struggle with the content.

In order to facilitate the goals of the Project, several changes have occurred in the roles and responsibilities of both students and teachers. This case study includes an examination of these changes.

New Teacher Roles and Responsibilities

In congruence with the constructivist approach to learning embodied in the Project's goals and objectives, the teacher's job is viewed as teaching students to be self-directed learners. The Project acknowledges that this will require teachers to be knowledgeable about mathematics, technology, teaching under-represented populations and learning about, as well as having skills in, multiple teaching and assessment methods. The Project does not advocate eliminating teacher directed instruction, but it does advocate using multiple methods of instruction such as student-led discussions, teacher-led class discussions, small group work, and peer teaching.

The Project encourages teachers to view their own learning as integral and on-going. As discussed earlier, teachers can be trained by the Project in one of three ways. They can apply to write curriculum or, secondly, to be trained extensively as someone who can work with other teachers. Both of these trainings are intense, requiring an eight hour a day commitment (at least) for eight and six weeks respectively and take place on university campuses during the summer months. Writers are schooled in the philosophy of the Project and then given guidance in constructing the curricular units that are the textual component for the Project's curriculum. Mentor teachers receive intense training in the implementation of cooperative learning, the technology employed in the units (graphing calculators and various computer programs) and the philosophy of the Project. Additionally, some groups of mentor teachers have pilot tested the curriculum material with students attending a summer mathematics program and/or have worked in small groups with other teachers to create lesson plans for the existing curricular units.

In addition to writing curricula or mentoring, teachers can also choose to register to participate in a less intense ten week continuing education course. This class usually meets one night a week, close to home, and is designed to give teachers a background in the philosophy and the major tenets of the Project (e.g., cooperative learning, computer programs). These courses have been taught by a collection of people considered to have expertise in the different aspects of the Project. Recall that it is possible and not uncommon for teachers to participate in more than one kind of training over time.

All of the Project teachers who participated in an interview said that their Project experiences, both in professional development and in the classroom have changed, in some way, who they are as mathematics teachers. One teacher says,

> No matter if [the Project] stays or goes, I'll never teach the same again. I don't think that anyone involved in the project will. I don't teach the same in my regular classes. I question more. I make the kids tell me why more. I don't see how anyone could be the same.

Another teacher adds,

> I know that I will never, no matter what happens with the project, I will never teach the same again. Because, just of the changes that you go through. For one thing, I have tons more real world applications that I can do in my regular classes.

The teachers participating in the Project have had to make some changes in how their classrooms are organized and in how they participate in the teaching/learning process. At RCHS, the "[Project] teacher role means experimenting with new options; being uncomfortable with certain aspects." The changes teachers cited occur on a number of levels and manifest themselves in a variety of ways in the classroom. At the most basic level, teaching in a Project classroom means accepting that it is a different teaching experience and that there will be times that are unfamiliar, and for some uncomfortable. The aspects of teaching in the program that are unfamiliar to the teachers range from becoming accustomed to the students sitting at tables, to students working in groups, to the "hubbub" of almost constant student interactions, to making use of the technology.

Most of the RCHS Project teachers came to the Project with some familiarity with its basic tenets. In general, the teachers at RCHS are familiar with change and seek opportunities to expand their pedagogical and mathematical knowledge. Trying new teaching techniques, improving on adopted texts, using technology, creating their own "real world" problems, and adding and omitting certain topics are all practices that many of the teachers, including those not involved in the Project, have engaged in on a regular basis long before the development of the Project. For the Project teachers, teaching in the Project is an opportunity to use these teaching strategies on a regular basis. They now have access to new information about teaching and learning, in addition to a new curriculum.

At RCHS, teaching in the Project means making some changes and taking some risks. For example, some portion of each unit has been written so that the students will work in cooperative groups to solve a problem. Project teachers have to think about what cooperative learning means and they have to structure their classes so they are comfortable with the interactions and the student products. For some Project teachers, cooperative learning is a new technique, one which they have not used in their classes before. Several shared that they are not sure of the merits of cooperative learning, that they feel it is unproductive for some students, and that they find it difficult to grade group-produced products. The tensions present at RCHS as teachers come to understand and use cooperative learning are not necessarily different from the tensions present in any teacher's classroom when the strategy is first introduced, but cooperative learning is only one dimension of change undertaken by Project teachers. The following vignette illustrates some of the challenges Project teachers face.

Vignette

> *Thomas stands in front of the class. The day's topic is Venn diagrams. He has never taught Venn diagrams before. As far as he can recall, they are not a traditional high school curricular topic, and he is a little unsure about how the lesson will go. He is excited because using a diagram to represent data will be a new experience for this class and he is curious how they will relate Venn diagrams to the other ways they have learned to visually represent data. Since Venn diagrams are a new topic for him to teach, Thomas is also a bit anxious.*

He is having trouble predicting where the students will have trouble, what things he should emphasize.

Venn diagrams are a surprisingly complex visual representation of numerical data. The students have been given data collected from the Center for Disease Control (CDC) about the number of people in several virus exposure categories. When a person is diagnosed as having the virus, the physician is required to report the case to the CDC and an attempt is made to determine how the patient was exposed to the virus. In a written introduction to the activity, the students are introduced to the exposure categories the CDC uses.

Thomas begins the class by reading through the introduction with the students. As a class they spend time talking about why the CDC keeps track of this kind of data and about the technical aspects of the transmission of the virus that would make these categories seem like reasonable choices. Earlier in the unit the class spent a fair amount of time discussing what the virus and the resultant diseases are, how the virus is transmitted and what has been done to curb its spread. The students are well versed in this information and seem to connect with the new information about exposure categories. Since the beginning of the year the class has done several projects where they represented numerical information visually using graphs and charts, so the students agree that representing the data visually will be helpful in understanding what the data means.

Together Thomas and the students work through an example that is described in the text. He is using colored markers on the white board and the students are calling out answers, justifications and giving him directions about what to do next. They have just enough time to get through the example and talk about what the students need to work on for tomorrow's class before the bell rings.

As the students leave, Thomas reflects back over how the class went. The students seemed engaged. They did a pretty good job answering the questions that Thomas had. They could offer explanations and justifications for their responses. They had not had trouble with the calculations nor seemed confused by the relationship between the textual data and the visual representation. Their homework was similar to the example the class had worked together, but there were also a number of differences. Thomas says he is now anxious to see how well the students do on the homework and to see where they have trouble. He thinks that they might need to go over a more complex example in class tomorrow and he makes a note to think of a good example.

Discussion. Thomas is in a position familiar to many of the Project teachers. Preparing for class can mean learning new material and being prepared to present it using an unfamiliar teaching style. It can also mean teaching topics not always included in traditional texts or curricula. With all of these variables, teachers have had very different classroom experiences in which they have learned more about teaching, learning, students, mathematics and the contexts in which the mathematics is presented.

Learning to teach in the Project at RCHS has also given teachers more information about the Project itself. The single most prevalent concern voiced by a majority of teachers in the RCHS mathematics department is about the content of the curriculum. In general, they consider the curriculum to be a mixture of mathematical and non-mathematical information. Those teachers familiar with the text describe the curriculum as ways to present real-world problems in a manner that makes the mathematics more interesting and therefore more accessible to students.

Most RCHS Project teachers, and some non-Project teachers, do not feel that there is enough "mathematics" in the units. Some of the Project teachers said they supplement the curriculum with their own, more traditional activities. The following response was typical: "[Project] material is making students think about how they could use math, but [Project] problems have too much application and not enough out-of-context." For some teachers, the shift toward more problem solving and less drill is seen as good. "The [units] contain less drill and have students figuring things out together. They have students think a lot." Only one teacher is not concerned about the amount of mathematics content.

For most of the teachers the non-mathematical information is problematic at one time or another. One teacher shared that he did not feel comfortable with the Project material because he did not feel he knew enough to teach about some of the contexts or he was uncomfortable teaching about some of the topics. Another teacher offered that she struggled with the very first unit in the first year materials. In that unit she had to know about light, mirrors and reflection. She said that she was comfortable when it came time to talk about the mathematics, the angle measures and the calculations, but that the physics of the unit was something that she was not familiar with until she taught it. She added that she believes she will be more comfortable and do a better job the next time she teaches the unit.

Perhaps the unit that demonstrates this tension the best was the unit on the spread of a virus, the unit that Thomas is teaching. In this unit, the writers have attempted to contextualize learning about Venn diagrams, probability, and "fitting a curve" in information about a virus and its accompanying diseases. This, of course, means that the teachers have to talk and, in some cases, teach about the virus and the diseases. When asked about this unit in particular, some teachers felt that the information about the virus was important information for the students to have and that the scenario of a real epidemic that is of concern today offered fascinating mathematical possibilities. These teachers, even if they felt undereducated about the virus and the diseases or were embarrassed about some of the subject matter, saw the unit as something that could really motivate and interest the students.

A few other teachers felt strongly that it is neither their job nor their place to be teaching about a topic as controversial as a virus that can be transmitted through sexual contact.. Their difficulty in talking with their mathematics classes about the Center for Disease Control's documented exposure categories is illustrative of the tensions that arise from application-based or context problems that are integral to the Project curriculum. Most RCHS Project teachers are ambivalent about the context, the non-mathematical information, in a text unit. The context is what makes the mathematics problems real-world and accessible to their students. It is also an area where Project teachers feel under-educated or anxious about their teaching.

RCHS Project teachers describe their role in their Project classrooms in two ways. In the most popular response, teachers would give their interpretation of the Project philosophy about the role of the teacher. All of the Project teachers are well versed in the beliefs and the expectations of the Project with regard to their role in the classroom. Several of the teachers even prefaced their responses with "I'll tell you what they say it should be." RCHS Project teachers understand that the Project wants them to take on the role of facilitator in their classes, and some of them see this as the ideal for which they are striving. All of the teachers interviewed recognized that the Project ideal is not the reality all of the time in their classroom.

In the second type of response, RCHS Project teachers offered their perceptions of how things truly transpire in their classrooms. All RCHS Project teachers have chosen aspects of the Project for use in their classroom. Some teachers have chosen cooperative learning and are focusing their efforts on making cooperative groups an integral and effective part of their class. Other teachers have chosen the concept of "contexts" and have gone about educating themselves about the various contexts within which the mathematics is contextualized. Others have chosen the task of making the use of technology salient in their instruction. To some degree, each teacher deals with each of the Project's basic tenets. However each teacher began teaching Project classes with a different set of skills, knowledge and beliefs and each one has chosen his or her own path in making the changes required by the Project. RCHS Project teachers describe their role in Project classes as different from their role in non-Project classes. One teacher said: "the teaching style is totally different than in a regular class 'cause although I do some lecturing in the front of the class, stuff is more asking good questions, eliciting interaction from the kids. More I'm a manager ..." Another teacher describes her role as "{m]ore of a facilitator, making sure kids are on task, pulling things together after they're done with their group work, to make sure that everybody's gotten the necessary concepts ... Kind of a watcher as opposed to a feeder."

RCHS Project teachers also describe their role as teaching their students mathematics. Many believe that in order to get across the skills and make sure their students know the basics, they need to lecture and be more directive as the class or small groups work through activities.

Teachers as Learners

Most, but not all, RCHS mathematics teachers are committed to a traditional view of mathematics as represented in traditional text books and on standardized tests. With several Masters degrees in Mathematics, and an average of over eight years mathematics teaching experience, RCHS teachers are well trained in traditional mathematics. They have taught thousands of students and know that many of them have gone on to use their mathematical knowledge and skills successfully. For almost all of the mathematics teachers at RCHS, the new definition of what is considered mathematics, the one advocated by the NCTM and embedded in the Project, is a problem. For these teachers, in addition to working out what it means to teach a Project class, they must also grapple with this new definition of mathematics and what it means to know and be skilled in mathematics.

Vignette

> *Molly is a first year Project teacher teaching an introductory class. She and her students have worked through their first unit successfully and have begun the second. One of the activities in this unit requires that the students enter several columns of data into a spreadsheet, calculate additional columns, print out the results and answer some open-ended questions based on the data from their printout. Molly has instructed her students to enter the data and then print out one copy for each member of the group. After giving the students their directions, Molly begins to circulate around the room.*
>
> *The students have only limited experience with the software they are using, but working in their groups, and with periodic help from Molly, they manage to log in, enter the program, and enter their data. The students seem excited about their "adventure"; the noise level is high and the conversations are animated. Every group is making progress, but not without making some mistakes either in entering the data, entering the calculation commands, or printing out their documents. As the time passes, the individual groups are needing more and more help and the problems they are having are becoming more and more difficult for Molly to help them with.*
>
> *Class time is growing short and Molly is becoming frustrated. One of the groups did not save their data file and they have gotten into a predicament that Molly can not help them get out of. The group shuts their system down and re-boots, but they do not have enough class time left to re-enter their data and get a print out. Unless they come in after school, they will not have the information that they need to complete their homework. When the bell rings two of the groups are not completely finished. There is a flurry of students scrambling to print out what they have and a long line at the single class printer. Molly is exhausted and frustrated and is not sure what to expect from the students tomorrow. She makes a mental note to use part of her planning period to chat with another Project teacher who has taught this material before. She also reminds herself that those teachers who are now teaching in the Project for the second year tell her that it gets much easier as the year goes on.*

Discussion. Later, Molly says she feels like the class was a "disaster." She says, "The kids get themselves into problems that I can't even begin to get them out of. I just don't understand enough about the software to even begin to help them." Molly is not alone. Another teacher says that on the same lesson he "... spent almost all the class period just trying to get the data that is printed in their [unit] books into the spreadsheet and then printed out. We didn't even get to the math."

The contexts within which the mathematics appears, the cooperative learning groups, the graphing calculators, and all of the other aspects of the Project that are new to the teachers require them to acquire new skills and knowledge. The amount of material a new Project teacher must master can be overwhelming at times and Project teachers acknowledge that some days go more smoothly than others. Teachers who are teaching Project classes for the second year are sympathetic and assure first year teachers that the students become more adept at operating the technology and that, as teachers, they will become more skilled and more comfortable as well.

Some of the teachers had knowledge and skills in cooperative learning, graphing calculators, computers and other areas before they came to teach Project classes. These teachers talk about finding a way to coordinate the different components in the context of a Project class. As time passes and teachers begin to gain skills and knowledge and become more comfortable with teaching Project classes, the number of "good days" appears to increase. The students gain expertise as well, diminishing the frequency of necessary "non-context" instruction.

RCHS Project teachers have some content knowledge to learn or "brush up" on, and they have to learn how to implement all of the curricular and pedagogical changes in their own classrooms. For all of the Project teachers, this effort is time-consuming and sometimes frustrating. Still, as is true with cooperative learning and the use of technology, teachers do have "ahh, haa experiences" where the Project pedagogy or curriculum seems to facilitate the students' grasp of the mathematical content or skills, and they are intrigued as well as challenged:

> When you start teaching [the Project] you have to learn a lot of different things. You have to spend the time learning how to use the computers and the software. You have to experiment with new options in teaching and that means being uncomfortable with certain aspects. It means trying new things like group testing and stuff. You have to learn the new knowledge covered in the [units]. See, [the Project] gives you more real world applications. You have to read because the math isn't on the tip of my tongue.

After their initial training, Project teachers are invited to participate in ongoing staff development meetings which take place throughout the year. These meetings are intended to be opportunities for the teachers to receive additional training and to talk with other teachers who are having experiences similar to their own. Some of the teachers attend these meetings regularly, feeling that they are a resource or feeling a sense of commitment to the Project at a systems level. Some see their feedback to the Project at the state level as integral to moving the Project forward. For other teachers the meetings are yet another way the Project infringes on their personal and professional time, and they do not see the meetings offering any solutions to the problems they encounter on a daily basis in their classrooms. During the second year of implementation, the teachers who have participated in the most intense training are the ones who continue to seek Project training by attending meetings throughout the year.

New Student Roles and Responsibilities

In the literature published thus far, the Project does not spend much time explicitly describing the role of the student. However, given the statements about the curriculum and the pedagogy, one can deduce that students are meant to be active participants in their own learning.

Extrapolating from the statements made about the curriculum, students are expected to participate in problem formulation and problem solving activities, to communicate about mathematics, to reason mathematically and to make connections between mathematical concepts and across contexts. Students are expected to participate in group work and class discussions and to complete individual and group assignments and projects. When describing classroom activities, the Project literature says students should simulate real-world activities. It expects that they should generate mathematical definitions and equations, and be able to foster the translation of mathematical understandings from one context to another. In its literature, the Project also gives students some of the responsibility of self-assessment in terms of assessing the quality and the quantity of their own work.

RCHS Project teachers have little to say about the role of the student in the reform and in their classrooms. Teacher statements about their own role in the classroom, however, are clues to the role that the student must take. As the teachers move from lecturer to facilitator, the students moves from receptacle to active participant. As the teachers hand over responsibility for the actions and interactions that take place during the class, they believe that the students will take on the responsibility.

In general, RCHS Project teachers say that they have the same high expectations for the work that Project students produce as they do for the work that students in their traditional classes produce, but the teachers do expect student actions in a Project class will be different. In a RCHS Project class, the students are responsible for more than coming to class and doing their homework. Teachers see students as needing to participate in their cooperative group by explaining concepts that they understand to group members who do not. Students also have the added responsibility of exhibiting collaborative work habits by not "sliding" by or relying too heavily on other group members. They are also expected to be pro-active in seeking the help of their group when they need it. The teachers feel students should be active participants in class and small group discussions, occasionally give class presentations and do their homework.

The RCHS Project teachers believe that the nature of the work that the students are asked to do is different from what is asked of students in a regular class. They recognize that the students must learn how to use the graphing calculators, the computers, and the software. Additionally, students must learn how to work in a cooperative group, how to make class presentations, and how to do the research required to answer the questions posed in the units. Even the homework is different. Project homework requires students to write more, to read more, to be able to explain an answer, and to be able to work with problems that are presented in the context of some "real world" application.

Many of the teachers openly admit to being uncertain when asked what it is that students are to learn from participating in all this "extra work." Closely related to their concerns about the mathematical content of the units, most of the teachers are concerned that their students are not learning the basic skills, that they are not getting enough "math." They are concerned that the Project curriculum is not giving students access to the appropriate mathematical topics or that the topics are not being covered in enough detail in the curriculum. Most of the RCHS mathematics teachers share the belief that students need more drill and practice work than the text provides in order to understand the concepts that the units are covering. Some RCHS Project teachers supplement the unit work with additional "problems out-of-context." The units come with summary assessments, but all of the RCHS Project teachers have written their own assessments, sometimes choosing to include out-of-context problems in order to tell "if they really understand the mathematical part of the [units]."

Above and beyond all else, RCHS Project teachers want their students to have the mathematical skills and knowledge presented in Project curricular units. However, most of the Project teachers are not convinced that the work required by the curriculum will result in the kind of student learning that they are committed to. Consequently, they make adjustments in their classroom practices in an effort to achieve their desired results. It appears that the more congruent an individual teacher's beliefs and the Project's stated beliefs about what is important for a student to know and be able to do, the less the RCHS Project teacher tends to change the nature of curricular skill and assessment activities.

When describing the kind of work that they do in their Project class, RCHS students most frequently cite group work and the use of technology as primary focal points:

> The groups usually have three to four people in them and there are kinda specific times we work in group. Like when we work on the computers or when we did really bad on homework or a test and the teacher gives it back to us to correct, or when we do the [unit] activities or experiments. But you can also talk to each other when nothing else is going on, like when the teacher is taking attendance or something.

For the students, getting to work in a group means sharing opinions, getting the work done faster, and discussing problems. On the positive side, working in a group means that "You get to compare ideas, work things out, help each other with problems and stuff," and "... people are pretty good about giving their help." The students are also pragmatic citing the fact that some Project activities require more people to get them done.

Working in a group is not always easy. They find it difficult to be in a group with people they do not like. They struggle with what to do about the fact that they are working hard and someone in their group is not, and it is difficult for them to keep themselves on task in a group of people with whom they would really like to spend time socializing.

The students feel the groups are useful since they provide a group of people to turn to for help. They feel that they have been given permission to seek help from other students. But getting ideas from and understanding explanations offered by other students is not a task with which students necessarily feel comfortable or skilled. Some of the students said having so many ideas is confusing because they do not know how to choose which response is best. They are unsure of how to tell if the information another student is offering them is true, or how not to get confused by another student's explanation.

For students, the technology is one means of getting the work done. According to the students, technology (computers and graphing calculators) is used in their class at different times for different reasons. Computers are used periodically and almost always by the group when there is a lot of data to deal with. Calculators are used frequently by individual students with smaller data sets, when raw data is to be converted to an equation, or when the objective is to graph an equation.

All but one student felt the technology helps them learn the mathematics. They said it makes tedious calculations easier and quicker, and the visual images offered in terms of graphs and shapes make the data easier to understand. The students also feel finding and correcting mistakes in their processes is easier when they use the technology than when they work with paper and pencil. The students believe that working on the technology provides them with skills and knowledge they will need in the future, in a world that is becoming more and more technologically dependent.

RCHS students' experiences with the technology are not all positive. Two-thirds of the students expressed that they have had experiences where their lack of understanding of the technology has made it difficult for them to understand the mathematics that they were covering in class. Students said that making a command mistake, forgetting what the process is, or forgetting what the formula is, causes them the most problems. For a few students it does not go unnoticed that it is sometimes easier or faster not to use the computer but rather to use paper and pencil.

Most RCHS students learn to use the calculators and the computer by receiving instructions from their teacher or watching their teacher demonstrate the process "over and over." A few students have computers or calculators at home on which they practice. Most students rely on their teacher's expertise, not only to get them headed in the right direction, but also to get them out of trouble when they make mistakes.

About one-third of the students say they prefer to work on both the computer and the calculator in group. These students feel there are many computer tasks where more hands are helpful. There are many different programs on the computer--a lot to remember--and more minds are better. The work goes faster if everyone is involved. About one third of the students say they like to work on the calculator as an individual. Calculators are small and students tend to feel more confident about working on them; they feel they know more about the calculator than the computer.

Though the students talk positively about their Project classes, they do not always participate in class in productive ways nor do they always do their homework. Understanding how to participate in RCHS Project classes and understanding the consequences of different ways of participating are additional learning experiences that Project students, and teachers, have.

By and large, students found the Project math classes to be fun. The problems are different; the context is prominent. So is the group work. Students say the Project class is easier than a traditional class, but that does not mean that there is less work or that the work is easier. According to the students it means that the mathematics is easier to understand, that the mathematics is presented in a way that they feel makes it more accessible. Students believe the mathematics is less complicated, less number oriented and less repetitive. Students feel they spend much more time talking with other students and with the teacher about what it is that they are doing than they ever have before:

> We're working in groups. It's different from any other math. Not all numbers. It's more solving problems, finding the answer.
>
> Work out of booklets, work in groups. It's not so much of a teacher-students, it's more of a student-student thing. Instead of asking a teacher how or what to do, you ask another student.
>
> It is more toward life and society. More like story problems and problems and equations. We do equations, but it helps you in the real world more than like basic algebra.
>
> It's an easier way; hands-on math. You do about the same amount of work. It is more like one-on-one with the teacher. A lot of times you get to understand what you are doing a lot better.

Students say that the Project classes are similar to other mathematics classes they have been in because there is a text, homework, it takes place in a classroom, they have to work, some of the topics are the same, there are numbers, word problems and equations:

> It's the same amount of work and you're in the same environment.
>
> We have homework and books.
>
> Some of the problems are like it, some of the formulas.

Five of the students said that this level of sameness is minimal and that their Project class is not like any other mathematics class that they have ever taken, nor do they think it is like any other mathematics class they have had:

> Other math is just working with numbers, more basic. Here you work with real life, you deal with real life.
>
> It does have equations, but they go along with story problems and society's view. It's not strictly story problems.

Three students interviewed say they feel that if you strip away everything else--the group work, the computers, and the units--the mathematics is the same because the equations, the numbers, the word problems do still exist:

> You do the work. Some of the work is alike. When you're doing the actual problems it's the same.

For students the major differences in their Project class and other mathematics classes they have been in are in the interpersonal dynamics, the use of technology, and in the presentation of the material:

> The way they approach everything. The way they teach it makes you want to learn it. Like the [unit on epidemics] and the games. It's more hands-on. You work with the computer and the calculator.
>
> It's different. You have more freedom to say your opinion. There is no one right answer. It's more towards life instead of basic 1+1 addition.

When interviewed, students were allowed multiple responses and, as a result, four students specifically cited the different role of the teacher in Project classrooms, five pointed to the use of groups as a major difference, and four students cited the implementation of calculators and computers as a major difference. Three students said the contextualization of the mathematics in real life examples is, for them, different from other mathematics classes.

All the students said they like the class, but there are things they do not like about it. Usually their dislikes had to do with their group members and the difficulty of keeping everyone on task. At the same time, the group work was one of the biggest reasons students like their Project class. Class discussions are also a plus, as are the technology and the relation to the "real world," both in terms of problem context and their ability to project how useful what they are learning will be in the future. Overall, students think it is fun and, though it is more work, they believe they are learning more and will be well prepared for their future.

In general students feel as though there is more dialogue both between the teacher and the student and between students. The group work means that the classroom is decentralized, the teacher spends less time lecturing, and the students spend more time interacting. They have more one-on-one interactions with their teacher, and with other students.

> Other teachers, they focus more on teaching the math rather than you. You learn it. He wants you to keep it for more than a couple of days. He has *you* work the problems over and over until you get it.

This is not true all the time, everyday, for each student. As in other classes, RCHS Project students sometimes find the language difficult, the group dynamics frustrating, or the material inaccessible, but for most students the changes the Project has made in these areas are noticeable and have met with a positive response.

New Assessment Tools

In addition to changes in curricular content and teaching strategies, the Project has also created changes in the way students' grades are calculated and assigned. Because of the shift in content, teachers recognized there was a corresponding shift was needed in assessment measures.

Even though the focus here is mathematics reform at RCHS, some discussion of the state-level program is relevant as contextual information. The Project advocates using multiple forms of assessment and evaluation materials on the system, curriculum, classroom and student levels. On the system level, the Project is committed to monitoring its progress towards restructuring mathematics education so that mathematics is more accessible and more widely used by students. Toward this end the Project Assessment Committee is collecting pre-Project and post-Project data appropriate for evaluating its progress on each of its stated goals. Self-assessment is an integral part of the Project at all levels.

The Assessment Committee is also responsible for gathering data to determine what qualitative differences might exist between the reformed Project curriculum and previously existing mathematics education programs. The Project's Assessment Committee collects data on Project students' performance on a standardized test and on an instrument developed by the Project which reflects its goals with respect to student achievement. Because the Project emphasizes mathematical reasoning and higher-order thinking skills, one goal is to maintain current student performance levels on the standardized tests which are believed to measure low-level isolated skills. On the classroom level, the assessment focuses on the effectiveness of Project materials and professional development training.

All of the RCHS Project teachers have found assessing Project students to be problematic at one time or another. For the most part, the teachers are overwhelmed by the amount of information that they have on students. In addition to assessing through homework, quizzes and exams, as facilitators teachers are engaged in an on-going dialogue with students. When asked how they know what their students know and can do in the subject area of mathematics, most of the teachers said that they learned about their students through traditional paper and pencil means but also through working with the small groups, the students' participation in class discussions, group presentations, and/or portfolios/notebooks/journals. When transforming their assessments into grades, all of the teachers said that they prefer to give students points solely for the mathematical work that they do and that they try to avoid giving points for things such as participation in groups and class discussions.

In general, teachers say that the written products students produce are different from those students in regular classes produce. Project students have to write more. "They have to be prepared to answer the 'how come' question." Of special note is the role that homework plays in a Project class. Compared to traditional students, Project students do generate more written products. Project homework often requires students to explain how they reached an answer or why they believe a statement is true. This type of homework is more time consuming and more difficult to grade than traditional out-of-context problems, and it is nearly impossible to have the students grade them in class. Teachers have dealt with this tension in a number of ways. Some teachers omit assignments, others have the students do the assignments but grade only certain assignments or certain problems on an assignment. Others have the students do all of the assignments but do not correct any of them; instead they give students grades for attempting problems.

All of the teachers said that they have written their own assessments or used one that another RCHS Project teacher has written. When asked why they do not use the Project unit assessments, two issues arose. First, there is near consensus that the materials do not align the assessment questions closely enough with the unit material for the assessment to be a fair measure of what the student knows and can do. Second, the unit assessments never have out-of-context problems, a significant difficulty for some teachers because they do not believe that they will know if their students actually understand the unit's mathematical concepts unless there are some questions that test these concepts in isolation of a context. Assessments are considered a weakness of the Project material by all RCHS teachers. Yet, all of the RCHS Project teachers believe they are capable of writing unit assessments, which include contextual and non-contextual problems to capture what their students know and can do.

When students were asked how their teacher communicates with them what she believes the student knows, the two most popular answers were tests and "asking us questions." Answers that referred to written products such as exams, portfolios, homework, and notes were the most frequent. But answers which refer to interpersonal interactions such as "asking us questions" and "by watching us work" were a close second. Included in a number of the students' responses that referred to written products was a shift from the traditional teacher responding to a student via marks on their paper to the teacher responding to the student as they watched the student work through the process of producing a written document. One student illustrates: "When I don't understand something he'll watch me work an example and show me as I go what problems I'm making." And "She asks a lot of questions. She'll make us do the problems while she's up there."

The students were asked what mathematics in a specific curricular unit from their level, one first year (pilot) and one second year (pre-pilot), was important for them to know. Their replies were very specific: equations such as "Y=ab(raised to the)x" statistics, probability, Venn diagrams, graphs, formulas for volume, area and surface area. When asked how well they believe they know the mathematics from these units, most students thought they could do the formulaic calculations or construct the diagrams fairly well, especially if they were given the opportunity to review or to use their notes from that unit.

When asked how their teachers knew what they knew from the appropriate unit, they replied "give and correct homework and tests, ask questions in class, going back and doing mistakes over. Asking a lot of questions and working with students outside of class. Portfolios." In general RCHS students had fewer responses to this question than when they were asked generically how their teachers know what they know and can do. Students began their replies with a product response such as "our test" or "our homework" twice as often as with a process response such as "[t]he questions we ask ..." or "how I am in class."

When asked what their teachers look for in their work the students emphasized that it is most important for them to attempt to do the tasks. They believe that "getting into it" and getting the main point are more important than getting a correct answer. "It's quality not quantity. Effort. Basic background. If you're trying to use the techniques she's given you." But memorization, facts and accuracy are not lost. "Accuracy. If you got the idea. Can you show an example. Definitions. Do you know how to use words correctly? Formulas."

Most of the students feel their Project scores are better than their mathematics scores in past traditional classes. Many also feel that they could do better in their Project classes if they did more work (more homework, studied more). But they feel that they understand more in their Project class than they have in other mathematics classes:

> "At the beginning of the year I had a B, but it went down because I didn't turn in my work. They have improved so much. In middle school I thought I hated math, it had no meaning."
>
> "Cs. Probably the same. I could get a B if I worked on my homework a lot more. I understand this more than I did in the past."

Grades, for students, reflect a combination of what they know and what they are willing to do in their Project class.

The Project has used two types of assessments to measure student achievement. First, in order to provide the Project with data on Project students that can be compared to non-Project students at the state and the national level, the Project administered an early version of the PSAT. The first year's analysis showed that there was no significant difference ($p > 0.50$) in the scores of Project and non-Project students. Data on achievement at individual schools was not released. The Project also wrote and administered a criterion-referenced test with open-ended questions on topics deemed appropriate for all students whether they participate in the Project or not. The first year's analysis indicates that the Project students did significantly better than non-Project students on six of the ten open-ended questions and that there was no significant difference between the two groups on the remaining four questions. Because the assessments and the Project are so new, the Project uses these results tentatively, but considers the results encouraging.

III. THE CONTEXT OF CHANGE

When asked what they believe the future of the Project is in their department, teachers found it difficult to answer. Most RCHS teachers said they do not have much information about the Project's goals or how well the Project is doing in attaining its goals and, therefore, have a difficult time deciding what the Project's future in their department should be.

In addition to classroom teaching, some RCHS teachers are assigned to spend one period a day helping any student from any mathematics class who wants additional instruction. Usually, students come to these teachers seeking help with their homework. This can put non-Project teachers in the position of teaching Project students and material. Each day Project, and most non-Project, mathematics teachers encounter students who are in Project classes. Each encounter gives the teacher more information about the curriculum and students' responses to it. Teachers then weigh these experiences against experiences that they have had over the years with the traditional curriculum and their traditional students.

The Project, as it is piloted at RCHS, is not seen by most of the RCHS mathematics teachers as a program that could or should replace traditional mathematics courses. Historically, high SAT/ACT scores and graduates who report back that their mathematics training prepared them well for college are cited by RCHS teachers as reasons to maintain and in some cases enhance the traditional mathematics track, and the mathematics "basic skills" in the Project. RCHS teachers have had success in training students for the academic mathematics experiences that await college bound students, and they are committed to preparing their students for these experiences. All of the mathematics teachers believe the traditional mathematics classes (their content, teaching style and assessment) have served them and many of their students well. Most of the RCHS mathematics teachers are reluctant to give up what they see as the critical components of traditional classes or to give up the traditional track within their department. Still most of the RCHS teachers, including most of those teaching Project classes, believe that too many students are not being exposed to, or are not acquiring the mathematical skills and knowledge that they should. The Project is seen as an attempt to reach these traditionally unsuccessful students.

The RCHS mathematics teachers do not all agree on who these unsuccessful students are and therefore are not in agreement about who it is the Project is "good for." When the mathematics teachers were asked who Project classes serve, their responses varied from "I think that the low kids are really falling through the cracks. The Project material is more accessible and makes math more interesting for them," to, "We do a pretty good job with our kids who are on the extremes, with the really high kids and with the really low kids, but it's the kids in the middle that seem to get lost. This project offers something to the students in the middle." There does seem to be agreement among most of the RCHS mathematics teachers that the students who take the most advanced classes of Trigonometry and Calculus are not well served by the Project. Thus, the teachers say that the Project has potential for some or most of the students, but they do not share a single set of beliefs about who should or should not take Project courses and, therefore, the goals of the Project within the department are not universally defined or understood. Some teachers speculate that by the time the Project is fully developed and implemented, it will serve at least as many students as the traditional track.

These tensions and dilemmas lead teachers to be willing to look at the Project and what it has to offer but to do so cautiously. As one Project teacher said, "I'm not ready to abandon all that we've done in the past and I'm not against the project." Another teacher adds, "We should proceed carefully." RCHS mathematics teachers' understandings of the Project, its goals and its impact on students and the traditional mathematics curriculum at the state and school level differ. These differences mean that the teachers are assessing the Project using a variety of personal criteria. Most of the RCHS mathematics teachers see the total replacement of the traditional mathematics track as a mistake.

The students believe that Project goals are the same as the goals of the school in general, to prepare them for the future. All of the students interview, except one, are working towards a college preparatory diploma and all of the students say they are college bound. Some have specific career plans, some have general fields in mind, and some are very uncertain what their future options are.

When students were asked what mathematics is important for them to know before graduating, one third of them talked about discrete concepts such as measuring, times tables, and calculating area. Another third talked about traditional topics in mathematics such as algebra, geometry, and trigonometry. Some students were uncertain because they have not thought much about their future or because they have not thought much about what mathematics is. Students also make reference to having the skills that they think they will need to preform their job and to do well in life. They talk of needing to be able to balance a budget or to figure taxes.

One-third of the students said that they learn more mathematics than their friends in regular track classes. They cite examples of topics and skills (e.g. matrix, scatterplots, computers) that they cover and know their friends do not. One third of the students say that they are learning less mathematics. Their perceptions usually have to deal with the fact that the Project does not cover as many pages in the text or that there are topics or skills in another class, such as algebra, that the students recognize they are not covering in their Project class. The final third of the students feel that they are learning about the same amount of mathematics with over half of these students qualifying that they are approaching what they are learning differently or that in Project classes they learn "other stuff" in addition to the mathematics. This "other stuff" includes many of the same things that their teachers must learn such as the use of technology, small group work, and knowledge and skills related to the context within which the math is embedded.

The responses varied greatly when Project students were asked, "Do you think what you are learning in your [Project] class will prepare you adequately for what you are planning to do? One student was unsure, because he sees his future as uncertain. One student said that Project will not be helpful in the future because she does not believe her career field mathematics. One student replied, "Yes and no." "Yes" because the Project class "mak think things through," but "no" because he took the ACT and did not feel prepare

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IV. CONCLUSIONS AND IMPLICATIONS

What Has Changed for Teachers?

As one looks at the experiences of the River City High School teachers and students during the implementation of the Project, the question arises: how has this reform changed their behaviors, beliefs and attitudes towards how mathematics is taught and learned? There are several key points that can be gleaned from the RCHS experience.

The changes teachers are required to make are substantial. RCHS Project teachers are making changes in what and how they teach. In addition to changes in mathematical content, they are adding technology and real-world contexts to problems. They are trying to facilitate more, lecture less, and use more cooperative groups, games and projects. Some of the RCHS Project teachers are questioning and changing their beliefs about teaching and learning. They are using the Project resources to help structure these changes in their classrooms.

For these teachers, what appears to make the Project different from other new teaching ventures is the breadth and depth of the changes. Teachers are being asked to make changes in what they believe mathematics is and in what they believe about teaching, learning and assessment. Shifts in these fundamental areas translate into changes in the roles that the teacher and the students take in the classroom, the types of skills and knowledge that students are given access to, the tools used for teaching and learning, and the means and meaning of assessment and evaluation. All of these changes mean that teachers have to have knowledge and skills that they may never have used in a mathematics class, or perhaps have never used concurrently.

Teachers have invested a lot of time and energy. To embrace the Project in a classroom RCHS teachers have needed extensive and intensive professional development training in the multiplicity of teaching styles the curriculum demands as well as instruction in both the mathematics and the contexts of the mathematics. Teachers in this department work within a culture that encourages them to keep learning, to use Eisenhower monies to attend meetings to further their professional development, and to try new materials and new approaches to teaching. Teachers in the department share individual and collective histories of being involved in a variety of reform efforts within the mathematics community (e.g., New Math, the Project) and within the teaching community (e.g., individual student projects). These past experiences have enabled the Project teachers to participate in the training and teaching in a collaborative manner. In general, the RCHS teachers share materials, expertise, ideas and problems both with other Project teachers and with teachers who are not participating.

There is an on-going learning process. When a RCHS teacher begins teaching in the Project, there is still a lot for him or her to learn. A basic understanding of some of the philosophical tenets of the Project enables the teacher to begin to use these tools in his or her classroom, bu there is still a great deal of knowledge and skills to be acquired. When the RCHS teach implement these tools in their classrooms, their experiences teach them more about these and give them the opportunity to blend the tools and techniques with their own teaching

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course of three years of required mathematics, Project courses are considered a lot more work. This project seeks to empower its learners and has moved these students to ask some serious questions. The Project and the students are at a critical point in their relationship, a matter that cannot be overlooked if the Project is to continue to grow at RCHS.

Administrative support. Currently, the RCHS administrative staff and a few of the school district administrators say they are in support of the Project and its implementation at RCHS. The department has received funding and teachers have received time off to attend professional development conferences from these two sources. Administrators on all levels, however, have been absent from Project classrooms and lack intimate knowledge of how the Project plays out in the classroom. Without intimate knowledge of the impact the changes in the classroom are having on the teachers and students and the understanding that teachers will need long term intense support, it is not clear that the school or the district administration will be willing or able to support Project participants in the ways that they need to be supported. Because this Project has incorporated many of the very newest educational research findings and advocated classroom level changes, it is not possible to predict ahead of time all of the needs the teachers and students will have.

In addition, administrators have their own concerns. Maintaining the dual traditional and Project tracks is resource intensive. It has resulted in a slightly lower class size and a slightly increased number of classes taught by teachers in the department. It is also a scheduling nightmare. It nearly doubles the effort it takes to schedule teachers and courses in the mathematics slots allotted.. The placement of transfer students from other schools or within RCHS is also increasingly complex. Successful implementation of the Project will require ongoing communication between the teachers and the administrators and a commitment on the part of administrators to understanding what implementation of the Project means at a classroom level and to proactively being involved in the change effort.

Greater teacher awareness is needed of the impact of the Project. Teachers also need to be aware of the impact that Project implementation has on non-Project personnel both inside and outside their department and take an active role in creating a place within the department and the school that is comfortable for all whom the Project impacts. Furthermore, non-participating teachers may well have to become more active in the change effort if only because district and departmental resources will have to be shared.

Greater student involvement is needed. Students also need to develop more understanding of where participation in the Project fits into their school experience. They have to be willing to accept the work and responsibilities that accompany all the benefits they describe receiving from their Project class.

The Future

The future of the Project at RCHS is uncertain. It is clear that the teachers need ongoing support in their attempts to make the changes called for by the Project. Because the teachers are currently at very different places in their personal implementation efforts, the type and extent of support needed by the teachers varies. Teachers also must be willing to participate in ongoing significant professional development in the areas requiring change. Because these changes are large scale, they require a long term commitment from RCHS teachers as individuals.

Major changes have occurred. The Project and the participating RCHS teachers and students are a testimony to what the commitment and determination of a few can do to change education. They have taken enormous risks and made great strides in improving the mathematics education of secondary students. Now is a critical time in the development and implementation of the Project at RCHS. Those who were eager to join the effort are already involved and seeking ways to deal with the struggles that Project participation has brought them. Those not yet involved are looking to Project teachers and administrators for proof that the Project is not only successful but also worth the resources being poured into it. The teachers and students involved in the Project on a daily basis are key players who require an active support staff. All who came together to design and implement the Project, as well as personnel with whom and for whom participating teachers work, need to respond to the needs of those who are living it out.

Long-term commitment. The long term plans for the Project are not clear to most of the teachers--whether from the perspective of the mathematics department, the school, or the school district. It is difficult for teachers and students, those involved and those watching, at RCHS to make sense of their experiences in their environment without clearly articulated goals for implementation and growth of the Project.

Teachers and students are looking for conclusive data that the Project is worthy of their time and resources--that the Project will be a success at RCHS. That such data is slow in coming is not surprising. It will take even more time for state level evaluators to gather enough data on participating students, teachers, schools, and districts to make any conclusive statements about all the different aspects of the Project.

What will result? Meanwhile time at RCHS passes. Individual students, teachers, and administrators are collecting their own personal data via their experiences and their understanding of others' experiences. Some are furthering their commitment to making the changes the Project requests. Others are deciding to "wait and see" or to reject the Project at RCHS.

Will the Project be successful at RCHS? Among district and school participants there is no unified, clearly articulated set of goals, there is no long range plan of implementation and no plan to assess progress or problematic areas. Additionally, there appears to be no plan for dealing with the issues or areas individual teachers and students find problematic. There is also

CASE STUDY OF MOUNTAINVIEW HIGH SCHOOL MATHEMATICS DEPARTMENT

LEW ROMAGNANO
CURRICULUM REFORM PROJECT
UNIVERSITY OF COLORADO

1995

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FOREWORD

When faced with a challenge, a detailed story of someone else's experience in a similar situation generally is of strong interest. In reading someone else's story--be it political history, a chronicle of dealing with a family tragedy, or the story of a major business success--we do not expect to find a formula to apply directly to our own situation; instead we hope to find insight and inspiration. Thus, the story contained in this report should be engaging to individuals committed to educational reform in a local school context. It is the story of one school--or department within a school--engaged in fundamental reform of education for its students.

Similarly, one should not expect to find in this case a model for a specific educational reform to initiate in another locality. Every context is different. Each local school and community culture has its distinctions, each individual's and group's educational goals have different shadings, each setting has its own history, and each school has unique constraints to making change.

Not only does one formula not fit all schools, there is no specific formula for a given school. A central message of our case studies is that educational reform is a long-term process for which there is no detailed road map. It is an uneven process with highs and lows, failures and successes, but gradual movement toward greater and more profound learning for students.

What we can expect to find in this story are insights about new teacher roles, how students go about learning with greater depth of understanding, the context in which such shifts can occur, the challenges that must be overcome to initiate these changes, and actions taken by various parties to keep the process of change moving forward. Reflecting on someone else's story can be helpful in the process of developing one's own plans, collaborating with others to move the process forward, and helping students take responsibility for learning.

The Research Project. The case study reported here is one of nine--three each in science, mathematics and higher order thinking across the disciplines--conducted as part of the Curriculum Reform Project. The cases were studies of individual schools--actually a department within a school in the case of science and mathematics--in the process of solidifying reform. Each was selected because it was a successful example of reform. A researcher spent 20 or more days at the site to learn what changes they were making, the barriers encountered, how they overcame these challenges, the nature of their successes and their hopes for the future.

Site Selection Criteria. Sites were sought which had initiated reforms consistent with those recommended by leading groups in the respective field, e.g., the Curriculum and Evaluation Standards for School Mathematics (Commission on Teaching Standards for School Mathematics). Final selections were based on program outcomes including student test scores, enrollments in subsequent elective courses in the given subject area, and professional judgments about the quality of the curriculum provided to students.

Site Selection Process. The search process began with the solicitation of nominations from researchers and knowledgeable practitioners across the U.S. Key people at the nominated schools were contacted by phone to get additional information and written exchange of information followed. Selection according to the above criteria resulted in schools spread across the country with considerable variation in location (e.g., urban vs. rural), economic level and ethnic makeup of the communities.

Research Methodology. In each case the researcher was immersed in the activities of the school and collected a wide range of information. Data included classroom observations, interviews with students, teachers and administrators, and a variety of documents from the site. The voluminous field notes and interview transcripts were analyzed and an interpretative report written.

Cross-site Analysis. A cross-site analysis of the nine cases was conducted to gain perspectives that extend across the sites. An individual case is rich in description and context but does not contain the depth of analysis that can come from looking across a number of cases. Thus, the reader is referred to the Project's cross-site analysis. Main points from this analysis to bear in mind while reading this one case, however, include the following:

- The reforms being sought are profound and demand major changes in teacher and student roles.
- The process for achieving such reforms is complex and demands a long period of time to attain.
- The schools in these cases have traveled a considerable distance on the road to reform but have not yet "arrived."

These cases are presented largely--though not exclusively--from the perspective of the teachers at the center of the cases. This perspective reflects the nature of the reforms and the way they have been initiated in each school. This perspective may be particularly important for initiating change. Our cross-site analysis shows that changes in teachers' values and beliefs--not just greater teaching skills and techniques--are central to reform. While changes in student roles and student work are the ultimate "bottom line," these teacher changes are an important intervening step.

We hope your reading of this case stimulates both interest and significant reflection about reform activities in your school.

Ronald D. Anderson
Director, Curriculum Reform Project
University of Colorado

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I. INTRODUCTION

When mathematics is taught as a fixed, logically ordered body of facts and procedural skills best learned by repeated practice and memorization, students do not retain much. Further, they are unable to use what they might have retained in problem situations where mathematics knowledge would be helpful. Many teachers, parents, policy makers, and business leaders have begun to hear these often cited results of national and international studies of mathematics achievement. The assertion that traditional school mathematics curricula and teaching do not lead to useful mathematics knowledge for many students has led to a swelling chorus of calls for changing school mathematics and how it is taught.

The federal government, many states, school districts, and professional organizations of mathematicians and mathematics teachers have all published new guidelines for the content of school mathematics, how to teach that content to all students, and how to assess students' developing knowledge. These guidelines include, for example, the influential "standards" documents published by the National Council of Teachers of Mathematics (NCTM) (*Commission on Standards for School Mathematics*, 1989; *Commission on Teaching Standards for School Mathematics*, 1991; *Assessment Standards Working Groups*, Draft 1993).[1]

Teachers around the country, in schools large and small, have read and discussed these calls for change. Some have helped write new guidelines; many more have begun to rethink their subject and their roles as teachers. These days, the mathematics classrooms of these teachers look very different. The mathematics their students do each day, and the ways in which they do this mathematics, is changing. How do these classes look? What are these teachers teaching? How are they teaching it? What are their students doing? What are they learning? What issues have these teachers confronted as they have worked to make these changes in their classrooms? How has the process of change proceeded at these schools? Where might this process be headed? What can be learned from detailed descriptions and analysis of this process?

The following case study is an attempt to answer these questions by taking a close look at one school's efforts to change its mathematics program. Mountainview High School[2] was chosen for study because it was several years into a reform effort that was, according to evidence gathered by the school, improving the mathematics achievement of its students. Teachers at the school adopted a set of radically re-designed curriculum materials. They adopted and in some cases invented both instructional approaches and methods of assessment that were also radically different from the traditional whole-class lecture and individual seat-work approach. This site provided an instance of the day-to-day work of teachers and students doing new mathematics together in new ways. It also provided a vivid illustration of these efforts' attendant conflicts and controversies.

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[1] The growing consensus summarized in these documents is by no means universal. Some dissenters argue that these calls for change are untested experiments that will result in further deterioration in students' knowledge, and that what is needed is a return to the rigor of the past (Finn, 1993; Saxon, 1994). Others contend that these documents are political compromises that do not go far enough (Apple, 1992).

[2] All of the names that appear in this study are pseudonyms.

Data Collection

The conceptual framework that guided this study, and the literature review upon which it is based, are reported elsewhere (R. Anderson, B. Anderson, Varanka-Martin and Romagnano, 1993; R. Anderson, B. Anderson, Varanka-Martin, Romagnano, Bielenberg, Flory, Mieras and Whitworth, 1994). The author and two research associates[3] spent 20 days at the school during the 1992-93 school year. They compiled field notes while observing classes taught by all mathematics teachers, while attending planning meetings and meetings with visitors and parents, and while participating in informal conversations during their time at the school. They conducted baseline interviews with each of the mathematics teachers, and follow-up interviews with four of them. Sixteen students of these four teachers were selected, in consultation with their teachers, and interviewed. In addition, interviews were conducted with the school's principal, an assistant principal, the Director of Counseling, and the school district's Director of Program Development. Finally, the researchers collected samples of student work, curriculum materials, and policy documents.

This report is divided into four main sections. Following this introduction to the site chosen for the study and its recent history, the classrooms at Mountainview are portrayed in two vignettes. These vignettes are designed to illustrate the specific ways in which the mathematics interactions among teachers and students differ from familiar norms. After these classroom characteristics have been described, a second set of vignettes serve as the backdrop for a discussion of the context in which these reforms are being attempted. Teachers, students, administrators, and parents differ widely in their understanding of, and commitment to, these changes. There is no small amount of controversy associated with this effort to teach mathematics differently, and the future direction of the reform effort is uncertain. The final section of this report will attempt to provide a framework for understanding the process of reform at Mountainview High School.

The Site

Mountainview High School graduated its first senior class at the end of the 1992-93 school year. The school opened in Fall 1990, adding a fourth high school to a middle-class/wealthy suburban district respected statewide for its quality. When it first opened, the sprawling, red brick building housed grades seven through ten; a new grade was added each year. As the 1992-93 school year began, those first sophomores were in grade twelve, and a new middle school opened just up the hill. Hillside Middle School was now responsible for teaching grades six through eight and became one of two nearby middle schools that send its students to Mountainview.

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[3] The author is an Associate Professor of Mathematical Sciences at Metropolitan State College of Denver. Mary Ann Varanka-Martin teaches at Estes Park H. S., Estes Park, CO. She was administrative director of the Curriculum Reform Project while completing her Ph.D. in Science Education at the University of Colorado at Boulder during the 1992-93 school year. Kathy Davis is a doctoral student in Science Education at the University of Colorado at Boulder.

Each morning about 1,700 students travel to Mountainview on two-lane roads through new neighborhoods and open space, past walled-in tract developments, large homes on acre-plus lots, grazing horses and cattle. The school sits on what is, at least for now, the outer edge of a growing western state metropolitan area currently numbering over one million people.

Historical Context

A year before Mountainview opened, the district convened a "cadre" of teachers, administrators, and parents to plan the new school's academic program. Carol Jennings had been teaching in the district for years and was a well-known figure among mathematics teachers throughout the district and across the state. Her reputation for leadership and innovation—in her classes as well as at the state and national levels—made her a natural choice to head the new mathematics department. Carol and the other members of the school's leadership team chose "The Five 'I's"—Interactive, Integrated, Interdisciplinary, Individualized, and International—as themes to guide each subject area's curriculum. Against this backdrop, and soon after publication of NCTM's *Curriculum and Evaluation Standards* (1989), Carol Jennings made several important decisions about the mathematics program:

> The *Standards* came out in '89; that was our Bible ... [W]e wanted heterogeneity seven through ten, [a curriculum that] would allow math to be accessible to all students ... and we knew that we could not write the curriculum ourselves (12/10/92).

The new school was to have a mathematics program that would give all of its students access to the mathematics knowledge they would need to meet the district's developing mathematics proficiency list. The program was to be integrated, blending the traditionally separated disciplines of algebra and geometry, along with less traditional disciplines like probability, data analysis, and statistics. It would ask students to solve meaningful and realistic problems and tackle extended projects. It would group students heterogeneously, rather than tracking students based on prior achievement or some measure of "ability." It would stress cooperative learning and use of technology. And, sensibly, it would be based on curriculum materials already written.

The search began for curriculum materials that met these criteria. Her connections, developed through years of professional development activity, led Carol Jennings to choose a set of innovative integrated curriculum materials[4] for the seventh and eighth grades. When the school opened, all middle-schoolers enrolled in either "Hi-Five 7" or "Hi-Five 8." No algebra course was offered for eighth grade students.

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[4] *Visual Mathematics* (Bennett and Foreman, 1989) and *Math and the Mind's Eye* (Bennett, Maier, and Nelson, 1988).

For the high school, she chose a three-year, problem-centered, "interactive" curriculum that was being written and implemented in another state.[5] Sixty ninth-graders were enrolled in two sections of "INT I." These students had applied to take this class, in response to information sent to parents of all ninth-graders prior to registration. Carol recalled the process:

> The first year we had only about 60 that applied. So we checked them. We looked at their files, their ITBS scores, their 8th-grade grades. We tried to see if we could say they were heterogeneously grouped based on that information. Actually we felt it was perhaps skewed a little bit to the left, that we had more kids who had been unsuccessful in math. That's how we set up the two classes (12/10/92).

The remaining high school students enrolled in the traditional mathematics courses offered to accommodate transfers from other schools in the district and, as will be seen later, demands from parents.

The two sections of INT I were taught by Sandy Jansen, an experienced teacher who had worked with Carol Jennings at nearby Sky Trail High School. Sandy was excited about this new challenge. She had tried to change her teaching in "bits and pieces" but had found that approach frustrating. On the other hand, Carol told her that the INT curriculum "was just about the only one that really was understanding the breadth and depth of what the *Standards* are all about. It was the only one that was [designed] to do a full change."

During the summer prior to the opening of the school, Sandy and Carol traveled to a three-day workshop sponsored by the writers of the INT curriculum, and Carol team-taught with Sandy for the first few months of the school year. The district had allocated some start-up funds for purchase of textbooks, but the INT materials came in the form of black-line masters. The cost of purchasing and copying these materials used only a fraction of the allotted textbook money; Carol made good use of what was left.

> We went and bought resource books, manipulatives, [classroom sets of graphing] calculators, and got funding for at least one trip for the training ... We have quite a resource library for our teachers (12/10/92).

Sandy also incorporated some of the INT materials into her Algebra I classes that year, the last classes she would teach in the traditional sequence. Second-year teacher Larry Conrad, another of the original members of the mathematics department, was drawn to the INT curriculum's approach. During the first year, he visited Sandy's classes on his own time and volunteered to try some of the materials in his traditional-sequence classes.

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[5] Carol obtained permission to use curriculum materials developed by the *Interactive Mathematics Program* (IMP), a collaborative effort of San Francisco State University and The Lawrence Hall of Science at the University of California at Berkeley. IMP is the centerpiece of the reform effort at this school, because of its alignment with the goals of the school's mathematics department. However, because this study is not an evaluation of the quality or effectiveness of IMP materials, in this report the acronym has been changed to INT. The Curriculum Reform Project is grateful to IMP for permission to refer to its materials as we have in this report.

The eighth graders at the school were taught the first two units of the INT curriculum during the last half of the first school year. This meant that, as the 1991-92 school year began, the school had to offer two options for incoming ninth graders who wished to enroll in the "interactive sequence." The first option was a course called "Hi-Five 9." This course began where the school's eighth-graders had left off, almost a half-year into the INT curriculum. It was the interactive option for those who had been at Mountainview the previous year, and about 80 percent of those students chose this course. The second interactive option was a course that began at the beginning of the INT curriculum, called INT I. It was chosen by many of the students who moved to Mountainview from the other neighborhood middle school, and from other schools in this open-enrollment district. The remaining ninth-graders enrolled in courses from the "traditional" sequence, which began with Algebra I.

The school's second year thus began with a new group of seventh graders, an eleventh grade, and several changes in the administrative team, including a new principal, assistant principal, and director of counseling.

The 1992-93 year, the focus of the present study, began with only ninth through twelfth graders at the newly-separated Mountainview High School. To meet the demands created by the growth of the school to include grade twelve and the departure of two teachers, six new faculty joined the mathematics department. For the first time, each member of the department taught at least one class in the interactive sequence.

The students enrolled in the courses summarized in Table 1. Note that, as a result of the split between the middle school and high school, Hi-Five courses now carried the names "Hi-Five I" and "Hi-Five II." The number of sections of each course indicate growth from year to year in the portion of incoming students who chose to enter the interactive sequence.

The enrollment data for students in the interactive sequence, broken out by grade (see Appendix A), confirm this increase in enrollment. A comparison of the cumulative ethnic data from the interactive sequence with the ethnic data for all students shows quite similar distributions by ethnicity.

What mathematics content is contained in the interactive sequence of courses? What teaching methods were being employed? How were these classes different from the ones in the traditional sequence? The next section addresses these questions.

"Interactive Sequence"		"Traditional Sequence"	
INT I Hi-Five I	8 Sections 14 Sections	Algebra I	5 Sections
INT II Hi-Five II	4 Sections 6 Sections	Geometry	6 Sections
INT III	2 Sections	Int. Alg./Trig Pre-Calculus AP Calculus	10 Sections 4 Sections 1 Section
		Science-Math	2 Sections

Table 1. 1992-93 Mathematics Courses

II. THE REFORMS IN PRACTICE

The Goals of the Mathematics Department

The mathematics department's goals appear in many documents produced and distributed by the school. The following are excerpts from published goal statements that draw heavily on the language of reform:

> The mathematics department at Mountainview believes in the philosophy set forth in the *Curriculum and Evaluation Standards* published by the National Council of Teachers of Mathematics. The *Standards* state that a school curriculum should be organized so as to permit all students to reach their fullest mathematical potential. Students should learn to value mathematics, become confident in their own ability, become mathematical problem solvers, learn to communicate mathematically, and learn to reason mathematically. We believe the integration of math strands within math courses should be emphasized and the development of interdisciplinary curricula should be an on-going activity (Programs of Study, 1991-92, p. 50).
>
> As an integral part of classroom activities, the students will work cooperatively in groups toward common goals ... [they] will communicate thought processes through writing and verbal presentations including, but not limited to: POWs, self-evaluations, sharing problem solving strategies, and group presentations ... [Students] will be able to write and present a justification of their problem solving strategies ... use a computer to generate and process data for problem solving ... implement problem solving skills in practical applications ("Mountainview Goals", n.d.).

The department thus outlined a program "wherein students can construct their own understanding." The program integrates mathematics "strands," links content to real-world applications, and does so in a classroom setting that encourages cooperative group work and use of technology, problem solving, and emphasis on written and oral communication. Further, the department's goal was to do this for all students, by using alternative approaches to instruction and assessment in heterogeneously-grouped classes. As Carol Jennings noted, "tracking guarantees that whole groups of students will not be able to meet the competencies." Therefore, the school offered no general, remedial, or basic mathematics classes. Students beginning secondary mathematics study had two choices: interactive mathematics or Algebra I.

To begin this section, two classroom vignettes will be presented and discussed. The vignettes depict important features of the interactive classrooms at Mountainview and how these features might evolve for students over three years. They also hint at some of the issues that have become important as the interactive portion of the mathematics program has grown. The first vignette is drawn from videotapes and observations of the original INT students, which were made near the end of their third year in this sequence of courses. The second portrays students of two different teachers observed early in their first course in the sequence. We follow these vignettes with a more detailed description of the key features of reformed mathematics program that facilitate successful implementation.

Vignette 1: Three Years of INT

Presenting homework. By 7:05 AM most of the students had arrived for this "zero hour" combined class of INT III. For several weeks now, the 40 or so students in these two classes have been meeting for an extra period each Tuesday and Thursday morning. The school's remaining original INT students had decided as a group that they needed to make up some time before the end of the school year, now only three weeks away, if they were going to be ready for the new INT IV class next fall.

The students were seated at desks that were grouped together in threes and fours; about half of them ate doughnuts and drank juice or coffee as they pulled their materials out of backpacks. Larry Conrad and Sandy Jansen, the teachers of these classes and the school's two INT "teacher leaders," stood together against the back wall, next to a large half-empty doughnut box. Class began when Ms. Jansen, who had taught all of these students during their first two years at Mountainview, asked for presentations of work on the homework (see Figure 1). After a brief pause Kent, a junior from Mr. Conrad's class, volunteered, stepped up to the overhead, grabbed a pen, flipped the switch, and began to write as he said, "The way I found this out was with an In-Out table; you know, zero years, one year, two years. After one year it's 10,500. After 2 years it's 7,350."

1. Car dealers use the "rule of thumb" that a car loses about 30% of its value each year. Suppose you bought a new car in December, 1990 for $15,000. According to this "rule of thumb", what would the car be worth in December, 1991? In December, 1995? In December, 2000? Develop a general formula for the value of the car t years after purchase.

2. Clarabell has thought about how cars lose value. She noticed that a $20,000 car will lose about $6,000 of its value the first year, while a $10,000 car will lose about $3,000 of its value the first year. She figures that, since the more expensive car loses more value each year, eventually it will be worth less than the cheaper car. How long do you think it will take for this to happen?

Figure 1. The Homework Assignment for Today

Kent began his presentation by describing his use of an "in-out table"—a common approach introduced early and used often throughout this curriculum—to gather and organize data. His first "in" value was zero, and his first "out" value was the original car value of $15,000. To find the value of the car after one year, he subtracted 30 percent of the original value of the car from that original value to *obtain $10,500. He used the same approach on this new amount to find the car's value after two years, $7,350. Kent moved quickly to the task of finding a general relationship.*

> *So I started out by dividing the first year by the original total, which is 10,500 divided by 15,000, which equals .7. And then I, [pausing to check his notes] I divided the third year by the original, which is 7,350 divided by 15,000, and that's .49. And I found a connection, being that* $(.7)^2 = .49$*, so for every year you bring it up another power. So, you get this equation ...*

By looking for patterns in the data he collected, Kent found that there was a connection; the ratios of each of the successive "out" values to the original value were the same as consecutive powers of 0.7. Kent wrote the expression:

$$((1-B)^E)\cdot A$$

on the overhead, speaking quietly and pausing as he wrote each of the variables so he could add, at the bottom of the screen, that B (the base) stands for the depreciation rate, E (the exponent) for the number of years, and A for the original amount. Throughout the quiet classroom, students listened, nodded, wrote, and ate.

After a few moments of silence Ms. Jansen, still standing in the back of the room, asked, "Does everyone understand what that means?" Sally, speaking to Kent, said, "Wait, don't you have to divide by A?" This question initiated a several-minute discussion during which Kent tried to explain his thinking and a number of his classmates tried to understand his explanation.

Kent responded to Sally by saying, "Well, I made a longer equation and just simplified it down to that." He wrote the following "longer" expression, again speaking quietly as he wrote:

$$\boxed{\left(\frac{[A-(A\cdot B)]^E}{A}\right)\cdot A}$$

> *This [pointing to the top of the fraction] tells you the price after one year, and then you do it by the exponent and divide and that gives you the .7, the .49, and then times it by the starting price. Then you can simplify it down to that equation [pointed to his original expression].*

Mr. Conrad, who had been following the proceedings from the back of the room, spoke up. "You're saying that those are equivalent. Everyone buys that? No *questions?" Some students nodded in approval or said they agreed; others sat quietly. Kent returned to his seat, but Mr. Conrad persisted.*

> *Mr. Conrad: Kent, can you read that second equation to me?*
>
> *Kent: A minus A times B, to the power, divided by A, times A.*
>
> *Mr. Conrad: OK, I couldn't tell if that was a minus or a multiplication.*
>
> *Ms. Jansen: I understand why that first equation works. I don't understand why that second equation works.*
>
> *Kent: Because the second equation's the same thing.*
>
> *Ms. Jansen: Tell me how.*

Both Mr. Conrad and Ms. Jansen recognized that what Kent had written as his "longer" expression was not equivalent to the first one. However, Kent thought it was, and the two teachers pressed him to explain why. Kent returned to the overhead and, as he talked about "canceling," he scribbled over each of the "A"s within the parentheses with the overhead pen. He and several students who were now involved in the discussion had a give-and-take about why he did what he did.

Could it be possible that Kent began with an incorrect expression, "canceled" incorrectly (the As in the parentheses in Kent's expression cannot be canceled), and by luck ended up with a correct expression? Ms. Jansen said, "I see a flaw somewhere," and Mr. Conrad asked, "Kent, why don't you erase that and start all over with your second equation?"

Kent shrugged and said, "OK." He squirted cleaner on the transparency and wiped it clean with a rag. From the back of the room, Mr. Conrad tried to draw the rest of the class into the discussion. "Raise your hand if you're 100 percent convinced that those two equations are equivalent." Several students raised their hands. "How many of you still need to be convinced some more?" A few others raised their hands. Several students had yet to express an opinion. By now, Kent had erased and re-written his longer expression.

$$((\frac{[A-(A\cdot B)]}{A})^{B})\cdot A$$

Ms. Jansen smiled and exclaimed, "Ohhhh, I see." Mr. Conrad asked the class, "OK, how many of you see something different?" Amid the rumbling of student talk around the room, several students in the group right in front of Kent told him about the additional set of parentheses he included this time. Kent acknowledged *the difference, smiled at his friends' good-natured kidding, and restated the meaning of the expression.*

> *In these parentheses [pointing to the outer set in the expression], you get the .7, the .49, and then you times that by the original price and that'll give you the price after that many years [pointing to the E in the expression].*

By asking Kent to rewrite his expression, Mr. Conrad and several students found out that he had simply transcribed his notes incorrectly the first time. Kent's second attempt was not only consistent with the shorter expression he had started with, it also portrayed how he arrived at that summary expression. Kent had more to say about his homework.

> *And you can graph this [pointing to the first expression] on the calculator and trace it and it fits the points on the In-Out table. [Pause] And then, the second part was when you did 20,000 and 10,000. Use this same formula, and put them in the calculator, and when you go down to one-hundredth of a cent they still never meet.*

Kent had used a graphing calculator (each classroom has a set, and many students have purchased their own) to confirm that his expression fit the data he collected, and to answer homework question two.

Ms. Jansen, speaking to the class, asked "OK?" After a quiet moment, she turned to Kent and said "Thank you, sir," and walked to the front of the room as Kent returned to his seat and the rest of the students turned their attention to her.

Kent liked to present because it gave him the chance "to explain things that [he] learned to the rest of the class and see if it's the same thing other people found." He also recognized another important reason for presenting:

> *You learn a lot more going up there and not knowing exactly how to do it and having somebody help you, than sitting in your desk and watching somebody else do it and just kind of pulling it off (5/26/93).*

Student presentations of homework, of one of the more involved "POWs" (problems of the week), or of the work done by a group on a problem during class, were a daily feature of all INT classes.

In today's homework students were asked to derive a functional relationship from a familiar situation. Kent recounted to the group how he derived an expression for the depreciated value of the car, which decreases by a constant percentage each year, by first gathering some data using an "In-Out table," and then looking for "connections." He summarized the connection he found using symbols that had meaning to him. To convince himself, and the others in the class, that his *exponential relationship worked, he graphed it and checked to see that it produced the values he had computed for the first few years.*

Kent had to work, however, to convince everyone that his expression was correct. The teachers and several students pressed him to justify his argument. He had, in fact, written something incorrectly when he tried to show how he found his expression, and with the prodding of the teachers, he and several classmates were able to find his mistake.

Today's assignment appears nearly a month into a unit that began with the problem stated in Figure 2. Solving this problem requires making a prediction based on data; in addition to experience with the process of reasoning from information like this, students must have an understanding of exponential growth and the properties of exponential functions in order to make a reasonable prediction. By attacking a series of related problems, the students develop the concepts of average and instantaneous rates of change, examine the characteristic rates associated with linear, quadratic and constant percentage growth functions, and connect these concepts to the context provided by the unit problem.

After fifteen minutes of class, with consensus reached on the solution to the homework, Ms. Jansen prepared to shift the focus of the students to the day's class problem. Today, students would be asked to use the results of several previous activities and assignments in a novel exploration of Euler's constant, "e."

Everyone knows the world's population is increasing. Here are some numbers that show the changes over history:

Year	Estimated Population
1000	340,000,000
1650	545,000,000
1800	907,000,000
1900	1,610,000,000
1950	2,509,000,000
1970	3,650,000,000
1990	5,300,000,000

If the pattern of this data continued, how long do you think it would take until we are all squashed up against each other?

The total land surface area of the earth is approximately 57,500,000 square miles. (This is about 30 % of the earth's total surface area.)

Figure 2

Today's problem. *Ms. Jansen stepped to the front of the room and, pacing back and forth as she spoke, made the transition to the next part of class. "OK, true or false: I can represent any number in one base as another number, in a different base. In other words [stepping to the overhead], I can represent 3 to the x as 5 to the something." Many students, in unison, responded, "True."*

> *Ms. Jansen: I can do that with any bases, yes?*
>
> *Several Students: Yes.*
>
> *Ms. Jansen: So I can take a base of 1,008 and represent it as 4 to the something.*

In an earlier activity, students had been asked to use their calculators and a "guess and check" process to express powers of one base as powers of another (for example, 3^2 *is about the same as* $5^{1.37}$*), and then to find general rules to make these conversions. Ms. Jansen reminded the class of this before she moved on:*

> *Now I want to talk to you for just a second about what scientists have decided to do. They know the same thing you just found out. I can represent any number in any base, any way I want to. What they want to do is select one base, so that they compare everything, so that instead of saying [writing on the overhead], "Well, I don't know, is 4 to the .978 equal to 3 to the 1.24? Well, let's get out the old calculator and ..." You can't tell by sight. But you could tell if you compare 4 to some power to 4 to another power. It's real obvious which is greater and which is less. So, with that in mind scientists developed a base that they were going to use all the time when they were expressing numbers. And this base has a special characteristic about it.*

As she used her spray bottle and rag to clean the transparency on the overhead projector, the teacher continued to set up today's activity by gathering data from the students' work on the previous day.

> *Ms. Jansen: When we represented 2 to the x, and we found its derivative, approximately what was it?*
>
> *Student: .69.*
>
> *Ms. Jansen: [Writing on the overhead] And then we had 10 to the x, and its derivative was ...*
>
> *Same Student: 2.3.*
>
> *Ms. Jansen: 2.3. And that derivative is always going to be proportional to y, right? We talked about that.*

At this point in Ms. Jansen's review of previous work, the overhead display resembled that shown in Figure 3. One student grew agitated as he noticed that Ms. Jansen's verbatim transcription of the answers to her questions was missing *a key element. Mr. Conrad noticed this and asked him, "Dave, so the derivative of 2^x is constant?" Dave responded, "The graph's not constant but the 'times the y' is." Ms. Jansen revised the overhead so that it reflected Dave's comment (see Figure 4).*

$2^x \quad y' = .69$

$10^x \quad y' = 2.3$

Figure 3

$2^x \quad y' = .69y$

$10^x \quad y' = 2.3y$

Figure 4

> *Ms. Jansen: OK? So that tells us that our derivative is always going to be proportional to y. Now the scientists were looking for a real special derivative that was real easy. What do you think the ratio would be over here [pointing to the constants 0.69 and 2.3] in order to make it real easy?*
>
> *Students: One.*
>
> *Ms. Jansen: One. If I can find something so that the derivative is one this is cake. With that information ...*
>
> *Dave: Wait, does that mean where the derivative is the same as the y value?*

Another student nodded and said, "Ahh!" Ms. Jansen paused for a moment to emphasize the point, then told the class to turn to the next activity in their packets and be ready to present in ten minutes. The noise level in the room grew quickly as some students got graphing calculators from the classroom set stored in the front closet while others began to discuss what they were to do. The two teachers circulated from group to group as the students worked on the task at hand for the remaining twenty minutes of the period.

Ms. Jansen's students gathered in the same room later that morning for their regular third-period class. The teacher began by assigning students to new groups of four, noting that these would be the last groups for this school year. After about ten minutes of group work and without any obvious signal from the teacher, Lori stepped to the overhead to present her group's work on the activity they began earlier this morning. Ms. Jansen called for the attention of the class, and Lori began by restating the problem as she and her group understood it.

> ***In our other homework and this morning, we found that 2 to the x was .69 times y, and 10 to the x was 2.3 times y. So, we want our derivative, or this part, to be equal to 1. So, we know 1 is between these two so we know the base is going to be between 2 and 10. So this is what you need to find [pointing to what she had written on the overhead, shown in Figure 5], that "a" so that the derivative is this right here.***

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2^x	.69y
a^x	1y
10^x	2.3y

Figure 5

Lori described that her group made an initial guess of a = 3, found the value of 3^x when x = 0, and then estimated the derivative at that point by finding the slope of the line connecting two points on the graph close together and near x = 0. The value they calculated, 1.11, was greater than the desired value of one, so their next guess for "a" was 2.7. Following the same procedure once more, the group settled on a value of "a" of 2.74.

When Ms. Jansen asked, "Do you guys have questions for Lori?," several students who had had trouble following Lori's presentation asked for clarification. During the give-and-take that ensued, Ms. Jansen sat in the back of the room and wrote in her grade book as Lori and the others in her group responded to queries from other classmates. One student wondered about the effect on the answer of rounding off decimals. Another noted that he had found derivatives at x = 4 rather than at x = 0. This approach produced different values for both the derivative and for y, but when "a" was about 2.7, the derivative was still about the same as y.

A third student seemed confused about the meaning of the derivative; a fourth classmate used the phrase "instantaneous growth" in the explanation he offered from across the room. When Ms. Jansen asked for the difference between the slope and the derivative, a fifth student said, "The derivative is the instantaneous slope at a point, and the slope is between two points."

As the class reached agreement on a base value a little above 2.7, Lori returned to her seat, turned to Ms. Jansen, and asked, "Was that a V-'check'-C-D-R?" The teacher looked at the "block assessment" she had recorded in her grade book and nodded, agreeing that Lori had Volunteered, that she had grasped the Concepts, Demonstrated good mathematical communication, and had Reasoned mathematically.

Discussion. This vignette provides a sense of the classroom tradition (Cobb, Wood, Yackel and McNeal, 1992) that has been established after almost three years of INT at Mountainview High School. It draws from a variety of data sources, including interviews with teachers and students, samples of student work, and transcripts of videotapes of three days of INT III classes conducted in late Spring 1993.

Several aspects of this classroom tradition are highlighted: the mathematics being explored, primarily by high school juniors; the flow of the class from group work to whole-class presentations and back again; the struggle of students to make sense of the mathematics that they and their classmates are exploring; and the actions of the teachers as they influence the discussions and assess the results.

Of the 60 students who enrolled in the first INT classes almost three years ago, about two-thirds remained to participate in the classes portrayed above. (Half of those who left returned to their old schools when the district decided after their first year to stop providing busing to Mountainview for students from other neighborhoods.) Aside from volunteering to come to school early two days each week to do more mathematics than their schedules required, these students and their teachers interacted mathematically in ways that differ from interactions seen in most classrooms.

The first major difference was the mathematics itself. The content of these interactions was advanced; for example, the topic of exponential functions is commonly part of junior-level mathematics courses, but it is not common for heterogeneously-grouped juniors to be exploring the rate of change of these functions using the derivative, a calculus topic. The organization of this advanced content was also different. Rather than being part of a textbook chapter on exponential functions, these topics arose out of student explorations of problem situations in which this and other content was imbedded.

The second major difference was the nature of these student explorations. Kent described for the class how he gathered and organized data, searched for patterns, summarized with symbols the pattern he found, and tested this summary to see if it was consistent with the data he had compiled. He then used his summary expression and its graph to answer the questions posed in the homework problem. Lori presented her group's "guess-and-check" process for solving the in-class problem for this day. She noted that their work drew on results of two earlier problems. She re-stated the problem as they understood it and described their reasoning each step of the way.

The central role played by these students' presentations of their work, and the discussions these presentations spawned, illustrate a third way in which these classes were different from traditional ones. The focus in these INT III classes was on the students' efforts, individually and in small groups, to make sense out of problem situations and their classmates' struggles to understand these efforts. The presentations made by Kent and Lori offered ideas for public discussion and critique. These students assumed prominent positions as leaders of, and participants in, discussions with each other and with the teachers.

Throughout the two classes portrayed in this vignette, the teachers assumed the familiar position at the front of the room, speaking while the students listened, for only about five minutes. Ms. Jansen took this time to set the stage for the day's problem. For the remaining time, the teachers moved physically and pedagogically away from the center, joining the students as mathematical sense-makers and assuming the roles of problem poser, discussion participant, and observer. This is the fourth way in which these classes differed from the norm.

While students worked in groups, the teachers circulated, asking questions and listening to students. During the whole-class presentations, the teachers stood or sat in the back of the room asking questions of several types. Ms. Jansen instigated discussions by wondering if anyone had questions for Kent and Lori. Both she and Mr. Conrad pressed Kent to justify an assertion. Mr. Conrad helped to resolve a difficulty by asking Kent to rewrite his expression. During her setup of the day's activity, Ms. Jansen asked a series of more directed questions to review results of previous problems. As this dialogue developed, Mr. Conrad noticed that Dave disagreed with some of the responses to Ms. Jansen's questions and asked him for his input. Later, during Lori's presentation, Ms. Jansen highlighted an important mathematical idea when she asked for the difference between the slope and the derivative.

Throughout Lori's presentation, Ms. Jansen sat in the back of the room and wrote in her grade book. She was keeping a record of the students who participated in the discussion and the nature of that participation. Lori understood the scheme and the criteria used by her teacher of three years; her self-assessment matched that made by Ms. Jansen.

Vignette 2: The First Year of INT

Two INT I classes

The first thing you notice when you step from the L-shaped, locker-lined hallway into many of the mathematics classrooms at Mountainview is the arrangement of the students' desks. Pushed together in threes and fours, they provide large work surfaces for the students who sit facing each other. With the teacher's desk out of the way and chalk boards all around, the placement of the overhead projector and screen is the only way to locate the "front" of the room.

Today the students in two different second-period INT I classes have their packets of copied curriculum materials open to the same page. In this unit, the 23 or so students in each class have been following the progress of several families as they travel across 19th-century America by covered wagon. At this point in the trip, the students are given data on the amount of water remaining in the supplies of three families at the end of each of several non-consecutive days. They are asked to graph the information for the three families on the same graph and use this information to determine if there is any time when the three families will have the same amount of water left, and whether any of the families will run out of water before reaching the next water source (a known number of days away).

In room 102, Ms. Garst walks from group to group as the students work on this problem. She stops at one point and has to say, "Eyes up here!" twice before she can get the attention of the class. She emphasizes for her students a suggestion *made in their packets that they might want to use different colors for the three graphs they are to make. As the groups return to their work, Ms. Garst asks the students in one group how they decided on the scales they were using for their graph's axes. Then she asks if they could estimate the water left for one of the families at the end of a day for which there was no data. One girl describes how she estimated the amount of water this family used per day, and then she uses this information to answer Ms. Garst's question. Before moving on, the teacher reminds the others in the group that they need to make graphs too, because they will need them to do tonight's homework.*

After a brief discussion with the next group, Ms. Garst asks its members if they would reproduce their graph on an overhead transparency so they could present their results to the class. They agree, and she gives them the three colored pens and "graph-paper" transparency she has been carrying.

As she moves from group to group, Ms. Garst repeats questions about graph scales, about estimating values on particular days, about the independent and dependent variables in this situation, and about finding best-fit lines. She notices that a boy in one group, working alone, had written a narrative answer to the problem. The teacher asks him, "Can you support your answer with a graph?" He answers, "No." She suggests that he get help from the rest of the group, and that he should also explain his approach to them. "This way," she says, "each of you will be able to do the problem two ways."

Meanwhile, down the hall in room 113, Mr. Monroe has asked one of his students to read the problem out loud for the class. As she reads, Mr. Curran is circulating, telling groups of students to pay attention. Mr. Curran is a resource teacher assigned to assist Mr. Monroe because over half the students in this class are classified as "pupil service" students. (This is Mountainview's "special education" designation. Mr. Curran spends three periods each day assisting in INT I classes.) Mr. Monroe interrupts the reader to ask an inattentive boy if he is on the right page. In a moment, after the room has grown silent, the reader completes her task.

Standing at the overhead, Mr. Monroe asks another student, "could you explain to the class what they want you to do?" After she re-states the problem, Mr. Monroe grabs an overhead pen and, as he draws coordinate axes on the graph paper transparency, asks several questions of the whole class. "What's going to go on the horizontal axis? What should the first value be? What should the last value be? Why? What interval should we use for gallons?" From the back of the room:

> *Mr. Curran: What are some ways we can make three different lines?*

Several students: Different colors.

Mr. Curran: How else?

Response: Dotted lines.

Mr. Curran: How will we tell the difference?

Same student: A key.

Mr. Curran: A key, that's right. Good job.

The two teachers circulate from group to group as some students begin working. One girl whines, "Do we have to use a whole page for the graph?" A moment later, Tim asks Mr. Monroe an interesting question.

Tim: Can't we say that they're going to start conserving water when they start to run out?

Mr. Monroe: Will the rate change if they did?

Tim: Yeah.

Mr. Monroe: Would that form a straight line then?

Tim: No. Does it have to be a straight line?

Mr. Monroe: That's what we've been doing.

Mr. Monroe asks a student in another group what he would predict for the amount of water one of the families would have at the end of a day for which there was no data. Using his estimate for the amount of water used by that family each day, the student offers Mr. Monroe a reasonable answer.

Planning for INT I. The Mountainview mathematics teachers are grouped into teams made up of those who teach the various sections of each course; these teams meet every week to plan. Only five of the fourteen teachers have class fourth period, so most of these meetings are scheduled then. (Some of the other meetings are held after school.) The seven teachers with two preps have two of these team meetings each week; the five with three preps have three.

One of the department's instructional leaders usually attends each of these meetings. Carol Jennings is the department coordinator, and as one of the original cadre of teachers hired to design the school three years ago she was responsible for bringing INT to Mountainview. She attends some of these meetings when she is not either hosting visitors or out of the building doing work for the school district. Sandy Jansen and Larry Conrad have the most experience teaching the INT curriculum. Each has been given one period per day of release *time this year to (among many other things) attend meetings of other teams in addition to their own.*

Sandy Jansen led the INT I planning session held just prior to the classes described above. The meeting began ten minutes into fourth period. (All but one of the team members came to the meeting directly from their third consecutive class of the morning.) As they thumbed through their copies of the teacher's version of the curriculum packet, their conversation followed two lines. Sandy noted specific aspects of the mathematics behind the "water remaining" activity—scaling graph axes, determination of the independent and dependent variables, and finding best-fit lines—and stressed that "these are decisions the kids need to make."

The group also discussed pedagogical issues: determining the appropriate size for groups; preparing graph acetates, colored pens and graph paper; encouraging students to use a full page for their graphs; incorporating use of graphing calculators in subsequent problems for which students will use the same graph-interpret-predict approach; deciding the sequence teachers would follow for the next few problems in the packet; saving one problem for use as an "assessment."

As the meeting broke up, Karen Barrow, who was hired so late in the summer that she missed all of the training workshops, asked Sandy for some advice as she struggled to grade the most recent POWs (problems of the week) turned in by her class. She had been able to sort her students' work into three piles—good work, acceptable, and "did nothing"—following criteria very much like those she used to assign "plus," "check," or "not yet" grades to the homework she collects regularly. However, she was having a hard time assigning points on the 0- to 6-point scale they had agreed to use for POWs.

Sandy asked Karen to describe what a "3" meant to her. As the electronic tone sounded signaling the end of the period, Karen described how she considered both the mathematical quality of the work and the effort put in by the student in awarding points. Sandy said that it is important to set a standard of acceptable mathematical performance and never lower that standard. She continued, "Part of the deal, especially first semester, is holding the kids to a standard they're not used to being held to." Karen gathered her papers, and as they left the room Sandy added that when she determines that a paper merits a "3," she tells the student that and then suggests what the student might do to make it a "4."

The Matrix Final. *Carol Jennings had a clear agenda in mind for the INT I team planning meeting held during fourth period on a December morning two weeks later. When Karen Barrow, Lisa Garst, and Carla Weiss entered the normally unused classroom, they found Carol sorting papers at the work area she created by pushing four student desk-chairs together. The first four stacks of paper* *contained copies of the work of three students. Carol had selected three students' answers to question number four of an exam taken by students, in class, a few days earlier (Figure 6). Four more stacks contained copies of the work of seven additional students. Carol had selected these samples from the papers collected in all eight sections of this course and had the department aide copy them prior to the meeting.*

All mathematics students at Mountainview take what the department calls "matrix" final exams. Through this process students get three chances to demonstrate what they have learned during the semester. The first chance comes in class about three weeks before the end of the semester. (The papers selected by Carol for this meeting were from this first administration of the semester's matrix final exam.) The second chance comes about two weeks later. The last chance comes at the end of the semester, during the regular exam period.

4. Two new telephone companies are trying to enter the local market, Ding-a-ling Telephone and Beep Beep Telephone. They decide to price their services in the following manner:

Ding-a-ling	$5.00 base fee per month .10 for each minute in use
Beep Beep	$8.00 base fee per month .06 for each minute in use

Using In/Out tables, rules, graphs, and your own mathematical power, compare the two services. In your discussion, include when it is better for you to use the services of Ding-a-ling and Beep Beep.

Figure 6: INT I First Semester Final A, Question #4

Each version of the test consists of four or five questions, and each question is keyed to what the team of teachers has identified as the four or five most important concepts explored by students during the semester. The questions change from version to version, but, for example, question four on each INT I test is designed to assess the same set of concepts as the question shown in Figure 6. A student's score on the final is made up of the highest scores earned in each of the five concept categories. Once a student meets the standard for one category she can ignore the questions that address it on subsequent versions of the test.

Carol explained to the INT I team that the purpose of today's meeting would be to check and refine the rubric, or grading criteria, they had developed during their previous meeting by using it to grade actual students' work. She then handed each member of the team one of the first sets of papers and a copy of the *rubric (Figure 7). They each read the first samples, assigned point values using the rubric, and then discussed their thinking in order to reach consensus. In one case, the three agreed immediately. In the second case, Karen Barrow changed her grade as a result of the discussion. She said that she had missed some of the mathematics the student had done. The group found the rubric difficult to apply in the third case, so it was revised slightly.*

At this point in the meeting, Carol gave each of the team members one of the stacks of seven papers (she kept one for herself) and the four teachers worked independently to assess their papers. When they were done, the grades were compiled on a single sheet for comparison. There were only three instances where the raters' scores failed to agree.

5	75 minutes has been determined as the amount of time where the graphs cross or in/out charts indicate change. Decision is given and he/she communicates when one is more economical than the other
4	Different slopes or rates are discussed--Decision is based on that information--Communicates why
3	Communicates prices for different times--Shows relationships between minutes and cost--She/he makes a decision about which is better
2	Student is on the right track--Not enough info generated to make reasonable decision
1	Attempted, but showed no understanding
0	No attempt

Figure 7. First attempt at rubric for INT I Final A, Question #4

The team agreed on the final version of the rubric for this question and spent the rest of the time they had together discussing possible answers and outlining rubrics for the other four questions. Karen and Lisa, who are also on the Intermediate Algebra/Trig team, left the meeting together, talking about the rubric they had devised for one of the questions on the matrix final in that traditional-sequence course.

Discussion. This second vignette portrays two different first-year classes conducted on the same day in late fall 1992. The students, and their teachers, were all in their first year in the INT curriculum. The vignette focuses on one activity from that first year, and it highlights three specific aspects of the program at Mountainview: classrooms that are already different from the norm—only three months into the INT sequence—yet different from each other; regular meetings of teams of teachers to plan instruction; and an innovative approach to assessment, along with some of the spade work necessary to implement it.

Eight sections of INT I were taught by five different teachers during the 1992-93 school year. The opening section of this vignette portrays a particular mathematics lesson as it took place in two of those classes, with two different teachers. These classes were similar in many ways. Most readily apparent was the physical layout of the rooms. Students sat facing each other in groups of three to four students, rather than in the more traditional rows of desks all facing forward. In addition, none of the students had textbooks; rather, they referred to their three-ring binders and folders, which contained packets of copied materials.

Each of the classes worked on the same problem on this day. They used two-variable data to create graphs, and reasoned from the graphs to answer a series of questions posed in their packets and by their teachers. The mathematics was noticeably absent of formal symbols, yet students confronted important concepts like summarizing data using best-fit lines, finding the rate of change of one variable relative to change in another, and making predictions through graphical analysis.

Each of the teachers in these classes spent a good portion of his or her time circulating from group to group, checking student progress and asking questions. Many of the same questions—how the students scaled their graphs, what they predicted for the amount of water remaining for a family on a particular day—were repeated with each group of students. (In each class, at least some students were observed using their own estimated daily rates of consumption to answer the "water remaining" question posed by the teacher.) Each teacher was prepared with the materials needed to have selected students use the overhead projector to present their work to the class, and students did present their work in each of the classes.

The two classes were also different in several important ways. Most striking was the presence in one of the classes of a second teacher, a resource teacher who is part of the pupil services department. In that class, there was more teacher talk. That extra talk took the form of more directed and convergent questions about the mathematics and good-natured encouragement for students to do their work. Finally, in this class there seemed to be more students working alone on the task at hand, even while sitting in a group with several other students.

Team planning sessions for each course were a regular part of these teachers' already crowded schedules. The first meeting described in the vignette provided an opportunity for one of the teacher leaders, in this case the teacher who had taught INT courses the longest, to share her experience with this lesson with the team. Many of the mathematical and pedagogical issues discussed in the meeting could be observed as similar features in both classes. The meeting also allowed the team to do some long-range planning.

The brief interaction at the end of the first team meeting and the entire second meeting were featured in this vignette to highlight the variety of ways in which these teachers assess their students. Students are assigned daily homework, work on "problems of the week" (a bit less frequently than once per week), are given assessments (some of which are included in the packets of materials), and take "matrix finals" at the end of each semester. These meetings also illustrate the time and effort expended by the teams devising, revising, and agreeing upon grading schemes and rubrics that accomplish the goals of: holding students to a standard of mathematical understanding; giving students the information they need to improve their understanding; and providing teachers with opportunities to learn in a group setting.

Key Features of the INT Mathematics Program

Taken together, the preceding vignettes provide a glimpse of classes at the beginning and at the end of the three year INT sequence at Mountainview High School. Several key features are evident in the INT program as it is developing at the school. In this section we provide a detailed description of those features.

Improved access to a broad mathematics curriculum. In order for all students to be able to demonstrate knowledge of number and number relationships, geometry and measurement, probability and data analysis, patterns and relationships, and algebra at outlined in the District Mathematics Proficiencies document (1992-93), they would have to have access to a broad curriculum. This access was provided at Mountainview by the adoption of the INT program as the "recommended sequence." Improving access also required the elimination of tracking. Several teachers described the ways in which mathematics of the INT curriculum was different:

> Instead of breaking it down into algebra, and then geometry, and then algebra/trig, it combines things together. You do algebra while you do geometry; it kind of mixes things together. It also throws in a lot more statistics than most students see in high school ... I see a lot more kids doing a lot more math (Lisa Garst, 3/12/93).
>
> It is an attempt to integrate algebra, geometry, trig, probability, and statistics all into a continuous curriculum. I guess it would be called a problem-based approach instead of being given a bunch of equations to grind out. They attempt to give a usefulness or a connection to a real world situation. Situations are provided so that students are given the opportunity to discover mathematics and develop it themselves. They understand why it works, not just that it works (Dave Jones, 3/12/93).
>
> There's a lot of probability and statistics in the early units, which kids normally wouldn't see until they'd finished three years of math. Some things that you'd expect a freshman to have done, some of our kids might not see until the second year, so the pacing is very different (Wendy Daniels, 3/12/93).

The students who had been in the interactive program for three years had perhaps the most important perspectives on the nature of the mathematics in their courses. They were aware of the difference in "pacing" described above by Wendy Daniels:

> High school math is high school math. Just because it's a different way of teaching it doesn't mean its going to be any easier. When I try to explain it to my friends they think it's like some math class that's behind everyone else, but it's not. I found a lot of times that I'm ahead of a lot of seniors who are taking their math classes (Carrie, 5/26/93).
>
> Over the summer I played Lacrosse with a lot of college girls and for some reason we got to talking about math and college courses. We're doing stuff right now that they're doing in their junior and senior year in college. So that made us feel so good ... At first [my friends] thought it was a class for stupid kids and then they found out we were doing college level math, so they just kind of shut up. I think it's funny. They're going to be asking me for help in college. It's fine by me (Laura, 5/26/93).
>
> I'm taking AP Calculus next year. I was going to take Precalculus, but I've already learned most of what they're going to learn and I don't want to do it over again (Kim, 5/26/93).

The need to provide access to mathematics also influenced the "alternate sequence" of Algebra I, Geometry, Algebra II/Trigonometry (followed by Precalculus and AP Calculus). Some of the most innovative texts available were being used for these courses, such as *Discovering Geometry* (Serra, 1989) and *Precalculus Mathematics: A Graphing Approach* (Demana, Waits and Clemens, 1992). From the perspective of Karen Barrow, who had taught for years but was new to Mountainview, "Traditional here isn't as traditional as it is somewhere else. What makes them traditional is they have a textbook."

Each of the teachers taught at least one INT class during the 1992-93 school year, and many INT problems were making their way into the traditional classes as "problems of the week" or as primary instructional units. For example, first-year teacher Mary Santoro related that "Interactive has influenced the way I teach traditional classes. I use the book as a resource, but I pull ideas from Interactive." Another example of this curriculum-materials overlap was the use in the precalculus courses, during the spring semester, of an entire first-year unit from the INT curriculum.

Focus on higher order thinking skills. Even though the mathematics content of the two sequences were similar in some ways, teachers and students noted important differences in the mathematics experiences offered by the two sequences of courses, in particular the integration of traditionally distinct topics, and the emphasis on understanding "why."

> INT is student-oriented rather than teacher-oriented. It's much more integrated with regard to the topics. It's probably more similar to when I was teaching elementary school (Jim Edwards, 3/11/93).
>
> INT makes you think more. There's a lot more writing. It's not all the formulas and all that. It's "Describe the formulas, how it works, and why." It's a lot more difficult that the traditional math class where you went home, did the formula you learned 50 times and then you had it memorized (Adam, INT III Student, 5/26/93).
>
> INT is not just a bunch of rules they give you. You have to grasp it for yourself (Rachel, Hi-Five I Student, 6/1/93).

For Larry Conrad, one of the two INT sequence teacher-leaders, the most challenging aspect of participating in students' work in groups and as a whole class is "the continual quest of listening to students and coming up with the question that is going to keep them moving" (12/10/92). Rather than presenting well-prepared explanations, the INT teachers tried to ask questions that would involve students in the process of devising solutions themselves. As several of his colleagues noted, the reasons for asking questions included getting students unstuck and determining student understanding:

> Mostly what I do is go around from group to group asking questions. When a group's off task, nine times out of ten it's because they're stuck. So you go over and find out where they're stuck by asking questions. Then I ask them questions, giving them as little information as I possibly can, and then leave ... I help my students by questioning them until they're unstuck and then getting out of their way (Sandy Jansen, 12/10/92).
>
> My main role is asking questions and sort of keeping stuff flowing, and keeping track of who's done what, when and who seems to understand this, who doesn't (Wendy Daniels, 3/12/93).

This focus on thinking skills and comprehension is not as apparent in other classes. These observed differences in the classes in the two sequences can also be attributed to differences in pedagogical approach.

Change in teacher roles and responsibilities. The vignettes that began this section portrayed classrooms whose "flow" differed substantially from the more familiar patterns of instruction. The teachers' roles changed as they prepared for, orchestrated, and participated as members of, these classes. The decision made prior to the opening of the school to adopt a set of curriculum materials eliminated the need for teachers to create problems and activities. However, the teachers had to prepare in two important ways to use these materials. The first aspect of preparation was familiar to teachers. It was organizing the "stuff" needed for class, and grading papers. According to Sandy Jansen, the time and effort required to do this in the INT classes was greater than even an experienced teacher might have anticipated:

> You're doing experiments, so you're pulling in rulers, string, washers, and setting that all up. You're also organizing calculators. You're also grading seven page POWs, so the load is heavy (12/10/92).

The second aspect was described by Carol Jennings as she reflected on her preparation to teach using the INT curriculum for the first time. She had one primary goal, and one important prerequisite for achieving that goal:

> When I began a unit, I would read through it to give [myself] an overview of the unit. I spent a lot of time studying, but also in planning my lessons. I wanted to be sure that I was going to provide for as many kids to be engaged as possible. During class you have to make decisions based on whatever the kids come up with. If you don't know where the unit is going or how much time you have, you can't make those decisions (12/10/92).

For Carol, knowing the mathematical goals of the entire unit was necessary so that she could make decisions, both prior to class and on her feet during class, that would keep her students engaged. This required studying the unit herself beforehand. Sandy Jansen had the most INT experience at the time of this study, and therefore was the teacher most familiar with the material. Her focus when preparing her lessons was also on the mathematics. "In each lesson there's a mathematical concept you want the kids to pull out. If you don't know that, you don't know what questions to ask." The content of traditional classes is typically a single topic, in a particular section of the particular chapter being studied. It seemed to these teachers that a problem-centered curriculum—one that brought lots of different mathematical topics to the fore for students—required teachers to prepare with more attention to the mathematical goals of a unit. Larry Conrad observed the analogy between this preparatory work of teachers and what they expected of their students:

> In the same way we teach INT, we actually construct for ourselves the meaning of a whole unit. Where are we going? I think that is one of the most crucial parts of teaching this ... knowing the mathematics (12/10/92).

Students in the INT classes spent a good portion of each class working in groups of about four students. During this time they either reviewed homework or wrestled with a new problem. Most of the rest of class time was devoted to student "presentations" of the work they did in their groups. The teachers' role, aside from providing this structure, was to participate in their classes. The most apparent means to these ends was through the questions posed by teachers. Many students noticed this very different teacher role, acknowledged its purpose, and the benefit to them:

> He usually sits in the back of the classroom and acts like a student who just walked in and doesn't know what's going on. So we have to go through the whole long process of how we did it. It really is [helpful] because everyone else is "Oh, that's where we messed up." He never gives in. He says, "Don't ask if it's right; ask if it's reasonable" (Laura, INT III Student, 5/26/93).
>
> She never answers questions. She doesn't do anything for you, and that focuses everything on us (Carrie, INT III Student, 5/26/93).
>
> You can keep calling her over, and she'll probably ask you the same thing: "Did you try this?" (Kim, INT III Student, 5/26/93).
>
> He won't tell you the answer; he never tells you the answer. When we get off track, veer off in the wrong direction in our mathematics, he'll bring us back in by saying, "What do you think about this?" (Adam, INT III Student, 5/26/93).
>
> She says, "Now, what if we did this?" She'll ask us a question and maybe give us the first part, and then we have to figure out the rest. This is better because then we have to struggle with the problem ourselves and find out why it works (Anne, INT III Student, 5/26/93).
>
> She's listening and she's writing out comments and after we're finished she goes back and asks us those questions about what we did (James, INT I Student, 5/26/93).
>
> She's just listening, and sometimes we ask her, "Is this the right answer?" and she'll be like, "I don't know." She won't tell us the answer, because we're supposed to be learning (Rachel, Hi-Five I Student, 6/1/93).

As participants in their classes, teachers strove to: set expectations for student participation and achievement; listen to and use students' ideas; provide a safe environment for students to participate; and shift the responsibility for mathematical sense-making from themselves to their students. This stance required teachers to give up an important traditional role:

> It's hard for a lot of people to say, "I'm no longer the center of attention. The students are." It's hard to give up that power. Because then the question becomes, "How am I the teacher if I'm not the one who is all knowing giving knowledge? What is my role?" I think that scares a lot of people. The biggest challenge is letting go (Larry Conrad, 12/10/92).

Change in student roles. The changes in teachers' roles also required that the role of students change dramatically. The students in the interactive classes were asked to take a much more active role in their learning. They were being asked to wrestle with problems—situations in which no path to solution was readily apparent—on a daily basis. They were asked to figure out how to solve these problems and why these solutions worked. They were asked to rely on other students for help, and to offer that help to others when they needed it. They were to turn to each other rather than the teacher. They were asked to take over the role of presenter from the teacher, even when they were not clear themselves. They were asked to deal with their inevitable frustration when trying to do something they did not already know how to do. Finally, they were asked to participate actively in the assessment of their mathematical progress.

Development of assessment tools that matched curriculum goals. The teachers needed to evaluate whether each of their students had achieved basic, competent, or advanced understanding of each of the district's mathematics proficiencies. More immediately, they needed to gauge each student's progress as she or he wrestled with daily work in class and for homework. For Larry Conrad, the goal of student assessment was to compile a "photo album" containing "snap shots" of each student's work during the semester. The department devised a variety of approaches to the task of compiling students' photo albums.

The wide range of assessment alternatives evolved, as described by Carol Jennings, because of the realization that "the traditional grading structure really didn't fit." She continued, "I don't think we're polished yet, but we're still developing. It fits with the whole direction that the district and state are taking." (Carol was in a unique position to know this. During the year in which this study was conducted, she was released from her teaching duties—which, as a department coordinator, were already reduced—to lead the district-wide effort to write mathematics proficiencies. As vice president of the state mathematics teachers organization, she was also privy to similar efforts in other districts and at the state level.) Some of these approaches are highlighted here.

Block assessment. The department's teachers all believed it was important to keep track of students' work in class. At one level, all of the teachers were interested in whether students were paying attention, whether they were participating, whether they were contributing to group work, and whether they were presenting. Dave Jones described the need for a different approach to document this work.

> A point total doesn't lend itself too well to the INT program, because what's valued is students' questioning ability, their insight, how well they can ask questions of other students in their group, to stimulate ideas (Dave Jones, 3/12/93).

He admitted that he was still trying to figure out how to do this. He was currently using a loose-leaf notebook in which he tried to keep track of students' class participation.

At a deeper level, some members of the department wanted to keep a more formal written record of student participation as well as the nature of that participation in class activities. Predictably, Sandy Jansen's block assessment scheme was well-developed.

> I'm looking at the student as a whole. Are you a student who is modeling learning behaviors? That may look different for every student. I have comment codes where I write down certain things. Are you volunteering to present? Are you using your group to learn? Are you helping others when they ask? Are you demonstrating good math communication? I evaluate them from the moment they walk in to class until the moment they leave (12/10/92).

Her scheme contained a Content block, an Attitude block, and a block called Dedication to Excellence. (A copy of her block assessment scheme is included in Appendix C.)

Just under half of the department used some form of "block assessment" in their classes. The variety of approaches used -- from keeping mental notes to documenting with written codes -- indicates the teachers' struggles to devise assessment schemes that they could fit with the goals of the program.

Student self-assessment. The INT curriculum materials included a number of opportunities for students to grade themselves. For example, all POW write-ups had this as one required component. In addition, however, several of the teachers required their students to reflect on their work for each quarter and complete a written self-assessment. For Larry Conrad, this was a crucial component of his overall assessment scheme. "I'm telling them I value their opinion in the context of the expectations I've set up." He outlined the process.

> They tell me which mathematical concepts they've learned and which characteristics they've demonstrated. Then they give themselves a "check," a "plus," or a "not yet," and why. "Check" means it's an acceptable level; they've shown understanding and they've communicated understanding. "Plus" means that they've gone above and beyond. "Not yet" means that they haven't reached the acceptable level yet (12/10/93).

A copy of the block self-assessment form filled out by each of his students is also included in Appendix C.

Problems of the week. POWs were an important feature of the INT curriculum materials. They were extended problems that required more than one night to complete. The INT curriculum also included guidelines for POW "write-ups." Students were required to restate the problem, to describe the work they did and the solution they obtained, to extend or generalize their work, and to reflect on and assess their own work. These guidelines were provided beginning with the first POW during the first week of INT I, and students were assigned POWs about twice every three weeks throughout their mathematics courses. As Sandy Jansen indicated earlier, by INT III, students were routinely submitting "seven-page" write-ups.

Many of the POWs included in the INT curriculum were very interesting and clever. Teachers are always looking for such problems, and the Mountainview teachers of traditional sequence courses, all of whom were also teaching at least one INT course during 1992-93, did not have to look far. As was mentioned earlier, INT content found its way into traditional courses through the use of POWs as a regular requirement in those classes.

Matrix finals. As described earlier, all students at Mountainview took matrix finals. These exams were designed to test students' depth of understanding of each of the five or so major concepts covered during the semester. They were structured in a way that gave students three chances to show their knowledge of each concept. Each course has a final constructed by the teachers of that course, and as the second vignette of this section portrays, significant effort is expended ensuring that students are held to a consistent standard of achievement.

Three features of this scheme should be emphasized. First, taking the final is meant to be a learning experience for students. The intent is that the first two administrations of the final would communicate to students what they are expected to know. Further, the teachers hope that students will use the feedback they get from each version to focus their preparations for the next version.

The second important feature of this department-wide examination policy is that it was almost universally liked by the teachers. Despite the extra time involved in designing and grading three versions of each final, the department's members approved of giving students more than one chance to show what they know.

The final feature of matrix finals is that teachers found the task of creating comprehensive exams containing only five questions much more difficult in traditional sequence classes. In a hallway conversation, Geometry teacher Tom Manning described for an observer how much time his team was taking trying to find a set of questions that would span the list of topics covered in their classes (Field Notes, 12/7/92).

Portfolios. Mountainview High School required students to compile portfolios of their work in all courses throughout their time at the school. These collections of students' best work were kept as part of the school's advisory program. (Each student had a faculty advisor; students met with their advisor once per week during a scheduled advisory period, and individually as needed.)

In addition, the mathematics department required each student to keep a mathematics portfolio. The INT curriculum included this as an explicit component. Students were provided with guidelines for selecting, at the conclusion of each of the five yearly units, certain pieces of work done during that unit. Dave Jones described the process.

> One day's assignment is to assemble a portfolio of work for that given unit. They select a favorite POW, favorite homework assignment, and then a third item of their choosing, be it classwork, homework, POW, assessment, anything they want. Then in their cover letter, they have to highlight the main topics that were covered in the unit, which of those topics they feel they understand, which they don't feel they've mastered. They're supposed to explain why they picked each of the items they picked (3/12/93).

Traditional-sequence students were to compile portfolios as well, but as it was with matrix finals, these courses had structures, such as discrete chapters of content rather than five-week problem-centered units, that did not lend themselves well to meeting this requirement.

The development of alternatives to traditional assessment schemes raised several important issues. The first is the degree to which each component was actually used by individual teachers. For example, only four teachers used block assessments consistently, several others used some modified form, and about one-third of the department's members rejected the idea.

The second issue derives from a scheme that recognizes that students' knowledge of mathematical ideas develops over time, and allows students to demonstrate that growth. In its purest form, this assumption conflicts with the arbitrary time periods at the end of which teachers are expected to give grades. Ms. Davis, the assistant principal who oversees the school's Pupil Services department, complained about one teacher's solution to this problem.

> Larry Conrad turned in 3rd quarter grades for a bunch of kids who had incompletes, with the idea that, 'I won't give them a grade until they've reached a competency.' The math department needs to have some discussion of what are the parameters in which we're working (6/10/93).

A third issue arises from the perception that alternatives to traditional assessment schemes, because they do not rely primarily on a percentage scale, are more "subjective" and therefore less fair. This issue will be explored more fully later.

These assessment issues hint at some of the vexing problems confronted by teachers, students, their parents, and school and district policy makers, as the mathematics program at the school evolved. The next section will discuss these problems and the conflicts they created among these constituents.

III. THE CONTEXT OF CHANGE

Mr. Newman, Mountainview High School's Director of Counseling, told an interviewer that "some of the best teaching methods will be found in the interactive [classes]." Some of those outstanding teaching methods and assessment approaches could also be found in the more traditional sequence classes. The similarities and differences across the two mathematics programs, and the variability across teachers within programs hinted at in the second vignette of the previous section, can be better understood when placed in historical and political context. This section describes that context and some of the controversy engendered by the sweeping changes being attempted by the Mountainview High School mathematics department.

Communication and Trust

In order to facilitate the implementation of the new interactive mathematics classes at Mountainview, the department's three lead teachers took on new roles and responsibilities. The coordinator was released from teaching during this school year; two "learning leaders" had reduced teaching loads in order to allow them to work with colleagues, many of whom were teaching the INT curriculum for the first time. The department's teachers were grouped into teams by the courses they taught. A structure was in place that provided for weekly meetings of these teams, to be chaired by one of the three lead teachers.

Yet, despite this elaborate structure of support and collaboration, large fissures opened up within the mathematics department as a result of the fundamental disagreements among its members. Breakdowns in communication eventually led to a lack of trust, as the following vignette portrays.

The meeting described in the next vignette never actually took place. It has been constructed from data collected by the researchers, including classroom observations and a series of two interviews conducted with each of the four teachers portrayed in the vignette. The issues that emerged from these interviews are fundamental, and the lack of communication about them across factions within the department have had profound influence on the reform efforts being undertaken at Mountainview.

Vignette 3: A Conversation

> *Four of Mountainview's mathematics teachers gathered one late spring afternoon for a meeting with a visitor. He had been observing classes at the school for some time and hoped to get a conversation going about some of the incidents he had seen. The five sat in student desks arranged in a small circle. "Two particular incidents stand out in my mind," began the visitor. "The first occurred in Wendy Daniels' Hi-Five II class last winter."*
>
> *Sandy Jansen sat across the circle from the visitor. She had taught every course in the INT program, and was one of its most articulate spokespersons. Mary*

Santoro was a first-year teacher who had sought Sandy's advice and counsel regularly throughout this year. She sat to the left of the visitor, listening intently, as he continued. "The problem for the day in Wendy's class was to determine the area enclosed in a regular pentagonal corral constructed from 200 meters of fence. As I watched the students working in their groups, I realized that they had not been given a formula for the area of a regular pentagon."

Mark Monroe and Terri Thompson sat to the visitor's right. Terri had made it clear to her co-workers, and to the visitor, that she was very unhappy about her first year at Mountainview. She sat back in her seat and looked straight ahead. Mark and Terri spoke often about their dissatisfaction with the INT program and the way it was being implemented at the school. Mark, an experienced teacher in his second year at the school, has just won one of the school's outstanding teaching awards. He was turned in his seat to face the speaker as the speaker continued.

One of the students presented her approach to this area problem to the class. She began by dividing the pentagon into five equal triangles. Another student asked her if the five triangles were equilateral. The presenter hesitated, but another student responded that if all five central angles added up to 360°, then each one was 72°. That meant that the base angles of each of the small triangles had to be 54°, so the triangles were not equilateral.

> *"The class decided that they needed to find the area of each of these equal-sized triangles, that they knew the base of each was 40 meters, so the key was to find the height. I wondered how these sophomores were going to proceed from here. I quickly found out. After a pause, Wendy asked the class, 'If you know one angle and one side of a right triangle, can you find the other parts?' The immediate response was, 'You could use trig.' I was really surprised to learn that these students had first encountered right triangle trigonometry when they were freshmen!"*

Mary described for the visitor that "problems generate the instruction. Through that, students start coming up against some concepts themselves, rather than being told, 'Here's the concept; now go solve this.'" Sandy added that the problem-centered approach often resulted in particular topics coming up in an order quite different from that of the more traditional topic-by-topic presentation. "The kids pull in the mathematics they need to solve the problem."

Mark spoke next. "I'm not sure what 'traditional' means anymore, but I do think that kids need some skills. There are certain things that kids need to know, and I think that if kids don't come in here with the skills they don't get it in the 'interactive.'" Mark had taught for eight years in another state before moving here. That state's guidelines for curriculum had changed while he was there, so he had already been incorporating topics like probability and statistics into his *algebra classes. He said that he doesn't see much difference, other than the emphasis on skill development, between that and the interactive program's curriculum.*

Terri agreed that the two programs were, in some ways, similar. "They say it's organized around problems, but we did a unit on probability, a unit on standard deviation, and a unit on geometry. I don't understand what the difference is, except that they have a packet with one problem a night and my kids in algebra have a book and they do ten." She also saw some important differences between programs. "I think some of the activities would be a lot more beneficial if there was a lot more meat to the program and the activities were incorporated into it. I really think there's a benefit to doing a bunch of problems along the same line, as opposed to doing one problem and then that being enough."

Mary asked Terri, "Don't you think that a lot of the 'problems' in most textbooks are really just exercises?"

"Kids," Terri responded, "need some successful practice doing what the expectations are. And besides, I get a lot more math out of my traditional classes than I do here. A lot of things in 'interactive' are creative, but the content's weak. I believe they're very far behind ..."

"Sure. If you walk into class you would know that INT I classes are geared toward the lower academic level kids," added Mark, supporting Terri, "whereas if you walk into an Algebra I class you would see it's totally different."

Terri continued, "... I think the program is good for some kids, like the ones that never felt like they could do math, but we do a disservice to a large part of them."

Sandy, trying to be as tactful as she could, interjected, "I have spoken with lots of visitors who ask if this is an accelerated curriculum because of what they see the kids doing. If you look at how much students do when they're developing their own process, their own procedure, they're not missing anything. If anything, they're gaining more content than in a traditional class." She wondered if Terri knew about the data the school had been gathering for parents about the effectiveness of the program for a wide range of students. Before she could outline those encouraging results, the visitor interrupted.

"The second incident I wanted to talk about occurred on a day when several teachers from other schools happened to be present in one of Sandy's classes. I was amazed when one of Sandy's students announced to her classmates that she didn't understand something, and then asked for their help." As he spoke, Sandy smiled and nodded, saying "Oh, Andee, yeah," as she recalled the incident.

The visitor recounted for the three other teachers what he had observed at the end of an INT III class discussion of a homework problem. "The student, Andee, waited for a lull in the discussion and raised her hand. When Sandy called on her she got up from her seat, stepped to the overhead, and asked the entire class for help understanding when to multiply and when to add when counting and arranging sets of things. She said she had never understood this. What surprised me as I watched this was how willing this teenager was to admit publicly that she didn't understand and needed help.

"One student joined Andee at the overhead and offered his thinking to her and the class, while several students chimed in from their seats. A second student stepped to the overhead and drew a picture to illustrate how she 'visualized' such problems. Sandy stood at the back of the room, adding to the animated discussion only once when she asked a student to clarify her explanation. It seemed clear to me as I sat there that Andee really wanted to understand this, and that lots of students in the class wanted to help her understand. The discussion went on for some time."

Sandy interjected, "I also have kids in my Hi-Five I class come up and say, 'I know this isn't right, but I'm going to present it because I don't understand it.' That's it; I'm successful as a math teacher if a student can do that."

Mark has been teaching INT I. Nodding his head, he said, "When kids come up at the end of the day and say, 'Monroe, I really didn't get that, man. Could you just touch base on it again?' they say to you that they know you're flexible enough to do that. If you have the involvement where the kids feel comfortable, they'll tell you a lot."

Terri glanced at Mark; she seemed surprised to hear him agree with Sandy. Earlier she had told the visitor that being sure her students could do their homework, that they could "get successful practice," was her guiding principle as she planned her classes. To her, a classroom incident such as the one described by the visitor would not make her feel successful, because that meant that the student had been sent home many times not knowing how to do the assigned homework. She said nothing to the group.

Meanwhile, Sandy wasn't sure Mark was agreeing with her. She wondered about his use of the word "comfortable." Was his goal to make students comfortable enough to ask him for help? Did his students expect him to explain things, to ease their discomfort? If so, then they did not agree. In fact, she had bluntly told the visitor that when teachers do this they help themselves more than they help their students, because it makes teachers feel good about themselves to provide this kind of "help."

However, it was Mary who spoke next. "I don't like to leave my classes feeling uneasy, but sometimes it takes that disequilibrium, to let them chew on it. I think they almost learn more that way because they go through some things in their minds, and then they try some things. They learn what doesn't work and why, and then come to some idea of what should work. They don't like it, but in my classes we've gotten to the point where they know I'm not going to leave them hanging forever."

Sandy agreed. "When you first do this with kids, they don't like you, because you're asking them to think and to do stuff they've not traditionally considered to be math. When I first started, it was really difficult for me to adjust from being the intelligent one in front of the class to being a facilitator. You turn into oil. You make sure the engine's running OK, but you're no longer the engine; you're the oil." Turning to Terri and Mark, she said, "My job is to teach kids how to be comfortable with being uncomfortable, to know what to do when they don't know what to do."

Terri shot back, "I think the whole idea of exploration is silly, if you have no idea what you're trying to discover. I think that's the problem with all of this. I think that if I could see my end and have my formula, and then ask, 'Where did this come from?' and explore, then I'd think it was cool if I got the same thing I was supposed to get. But if I just go and explore, and get something and have no idea what it is, I would wonder, 'Is it right?' We leave out a lot of learning moments because we don't do enough guidance. I think some kids will never get it if I don't tell them."

"It took me some years to realize," added Mark, "that it's nice to have the knowledge, and that's important, but if you cannot get it across to the students so they feel comfortable, then the knowledge is just your knowledge. When you see the excitement on their faces that says, 'I got it; I see it now!' then you know that you're doing a good job."

"I feel like I've done a good job when I haven't talked much in class," was Mary's response. "When my students just take off on a mathematical discussion, then they are thinking mathematically and discussing and reasoning and trying to put it all together for themselves."

Sandy wondered out loud, "Why would I explain to them my understanding? They don't need to know what I understand; they need to know what they understand."

Terri shook her head from side to side and said, "I try to instill a sense of excitement and enthusiasm for math, to create a setting where my kids feel good and will equate that with mathematics. I just think math is the vehicle. I teach kids, and happen to teach them through mathematics. I try to find a kid who *needs to feel good about himself that day and make sure he leaves feeling good. Then, if I get to the math, great. If not, I'll make it up tomorrow. The curriculum will never keep me up at night, but a kid's feelings will."*

Mark agreed with this. "I'm not necessarily a math teacher, but a teacher of kids. My goal is to try to meet the needs of my kids, to model my class so that it is the most positive learning environment for them. When kids talk to me more about things other than mathematics, then I know I've reached them."

Terri leaned forward in her seat and spoke directly to the visitor. "I struggled the first half of the year because I was what they wanted me to be," pointing in Sandy's direction without turning her head. "I was transparent. This is stifling to me. In Algebra, I can see if my kids get it, and if they don't I can pull resources and teach according to their needs. But here, they want you to be transparent. This is not what these kids need. They need structure." Terri paused for a moment, and then she lowered her voice. "Anyone can come in here and do this. What I have to offer is not valued. I'm disillusioned by the lack of respect as a professional. To me, the teacher is the center of everything that fails or succeeds in the classroom. The curriculum doesn't motivate kids; teachers do. We never talk about the teacher's role, and we never talk about kids. This is not a student-centered agenda at all."

Mark added, "That's true. At Mountainview, it's always curriculum, curriculum, curriculum. When the focus is only on the curriculum and there's never a focus on the kid, then that is frustrating."

Sandy felt as though she had to respond. "My job is to teach kids how to learn, to be self-sufficient, to use each other and themselves as mathematical resources. I facilitate, but I don't just open up a room and have materials there. It is much more active than that. I pose problems, ask questions, and set up situations such that the students' own curiosity—which we've killed up to this point—comes back. Have you ever watched a little kid? They're the most curious things in the world. If mom will stay out of the way, they'll learn amazing things. The mom has to provide a safe environment where the kid can't get hurt."

Sandy, who is called "Mom" by many of her students, continued. "I work harder in class this way than I ever did in traditional classes. I'm continually going from group to group, checking to see where they are, checking to see what they understand about where they are, thinking about what questions I should ask them to get them moving. During presentations, I wonder whether the class is understanding, whether I need to get them to ask more questions. I'm always 100 percent there. Now, that really bothers kids, but it bothers them because I'm putting responsibility on them and taking it off me. But if we make it all nice for them, they'll never learn to count on themselves and not on me."

The visitor noted that this was the second time the meeting had reached an impasse. He interjected, "How do you know when the kids are understanding?"

Sandy began her answer by saying that "If you're teaching differently, then the assessment's got to change." She described how she keeps records of students' work in groups, during presentations, and on homework and POWs. She said, "When kids present and the class reaches a consensus, I can pretty quickly run around to each group, ask where they are, and in two or three minutes know whether they're catching it or not. By the participation of each kid, I can tell you pretty quickly what kids have it and what kids don't yet."

Terri said, "I agree. I don't have it written down, but I know who does what. Any good teacher should know who volunteers, who falls asleep in class, who is chatty, who does what."

"I've told my students that everything they do from the time they walk in the door to the time they leave counts toward their assessment. I also assess my students as I'm walking around. I'm getting better at this. It takes practice." Mary and her students have worked together to revise her block assessment scheme several times during the year.

"I try to sit in the groups and see if they can communicate their understanding," said Mark. "I don't like to use codes. I like to use a lot more personal approach, saying 'Hey, great job today,' and just letting them know. I have also given regular tests. I've used my professional judgment to decide when I have to do that."

Buoyed by the more civil tone of the discussion, the visitor posed a question to the group. "How do you grade a student who does his or her work but doesn't understand the mathematics?"

Mary was the first to respond. "Well, there's a lot of professional judgment involved in combining mathematics knowledge, attitude, and commitment to excellence, but just because students worked hard, they shouldn't be getting a good grade."

Sandy added, "A 'check' on my assessment means you've shown an acceptable level of understanding, no matter how hard you worked. You've got to have standards. You can't just make kids feel good about themselves whether they understand or not. That's not what this is about, and that's a misconception that a lot of people have about this program."

"If a kid has shown a lot of hard work, a lot of desire," Mark asserted, "but still there is not some clarity in their understanding of the concept, I think there are

ways of evaluating that kid where he can still feel successful. On the other hand, if we've had 15 homeworks and the kid has only done two, I don't care if he understood both of them. There's a problem there, so I'm not going to reward him for doing nothing. I don't care what anybody says."

Terri was agitated. As she prepared to leave, she said, "I'm not going to be the one who changes a kid who has grown up getting little stars by being the first one who doesn't give them. No matter how much we want to fight it, that's the reality. Now this rubric thing. I'm fed up with the rubric! I gave a kid a '4', which was the equivalent of an 'A', for his work, because I was so proud of him for turning it in. For someone else, it might have been slop work, but I know his grade made him feel good, and I know it will make him want to do it again."

The bell rang, and the room emptied quickly.

Discussion. By the spring of the 1992-93 year, the mathematics department at the school had fractured into three camps of roughly equal size. The "interactive" teachers, including the department coordinator and the two learning leaders, were committed to the INT program and more generally to the changes it embodied. The "traditional" teachers disagreed with aspects of the INT program and its effect on the department's offerings; their dissatisfaction had been building and they had become more openly critical. A third group of teachers had taken positions between these extremes. They liked certain aspects of the new approach, were unsure about others, and were taking a wait-and-see position.

The four teachers involved in this preceding "discussion" represent extreme camps. The two groups disagreed with each other about all major aspects of their work as teachers of mathematics: curriculum, instruction, and assessment. Terri and Mark were convinced that the INT program was not appropriate for all students; in fact, they believed it was a course for low-achieving students because its content was weak. Sandy and Mary, on the other hand, were convinced that students in this program did more mathematics, and did it while developing their ability to do mathematics for themselves. The two interactive teachers viewed their roles in their classrooms as facilitators, questioners, and providers of safe environments for students to take risks. The traditional teachers thought the new approach removed them from the classroom; in their view it prevented them from helping their students and from connecting with them on a personal level. Sandy was adamant that students be held to a standard of mathematical achievement; Terri was sure her students would not engage in her classes without being encouraged for their effort.

The disagreements they expressed are fundamental to understanding the process of change at Mountainview. The issues are at the heart of the reform effort in progress in the Mountainview mathematics department, and the tensions among teachers grew out of differences in personal beliefs about mathematics, about the role of teachers, and about the ability of all students to learn challenging mathematics in meaningful ways. The fact that direct discussions among the department's members about these core questions did not occur would be important in any setting. It is striking when viewed in light of the amount of professional support offered to the teachers at Mountainview.

One of the most notable aspects of the work being done at the school to change their mathematics classrooms is the amount of professional support offered to teachers. Counseling Director Mr. Newman acknowledged that one of the strengths of the interactive program at the school was that "the people who began the interactive program had tons and tons of in-servicing" (6/7/93). The support structure in place for the entire department during the 1992-93 school year included: a two-week summer workshop for new teachers; a common planning period for most teachers; team meetings, scheduled once per week; the department coordinator and two "instructional leaders" who had one period per day of release time to attend these meetings and provide support for teachers; and opportunities for team teaching.

Additional avenues for professional support included: attendance at workshops hosted by the writers of the INT curriculum; opportunities to conduct local workshops and host visitors who wanted to learn more about the program at the school; and attendance at other regional and national meetings and workshops.

Some of the teachers in the department found this support system to be quite useful. Mary Santoro found the summer workshop "really interesting." For her, "It was just a taste of what I get now, every day." She also enjoyed the regular opportunities to pick the brains of the instructional leaders:

> They're very different in their approaches to this, in how they do things. It's a lot of fun to talk to each of them and get their opinions ... We have meetings for each of our preps. At times they're very beneficial. If somebody's been through this before, and they say, "Why don't you make sure you notice this," or "Here's an emphasis," that really helps me out. I don't have to come up with everything and second-guess what's going on (3/12/93).

On the other hand, some members of the department were not happy with the support they were getting:

> The staff development and what we got to facilitate this curriculum was not adequate ... We never talk about the teacher's role; we never talk about kids. We talk about curriculum. I can read the packet. I don't need to come to a meeting and talk about the curriculum (Terri Thompson, 3/12/93).

> I think there is less support than what it sounds like. One frustration is that the group I meet with, none of us has taught INT I before. The year started out that we had people that had taught it before come in and talk with us, and that kinda disappeared. Today we actually asked Sandy to come and help us, and she did and it was helpful. But I feel like we shouldn't have to ask (Lisa Garst, 3/12/93).

Lisa Garst described a breakdown in the intended structure. She also echoed the comments of many in the department when she complained that communication among members of the department was a problem. By early April the strains among the factions in the department were so great that, with the support of the administration, the entire department was released from school for a day. The teachers attended a retreat away from the school complete with an outside facilitator hired to help the group to communicate better. Afterward, several teachers expressed appreciation for the recognition given to the problem but guarded optimism about the prospects that the situation would improve. Lisa Garst hinted at a divisive issue:

> I see Larry, Sandy and Carol are so 100 percent completely sold on Interactive that they refuse to see any problem with it. They haven't been in a situation where they've had to teach INT I with all Pupil Service kids in it. So I think they kinda have blinders on (3/12/93).

Lisa was not teaching one of the INT I classes with a large number of Pupil Service students either, but two other members of the INT I team were. They had large classes with half of the students identified by the school as being in need of pupil services. In the INT I classes these services included a resource teacher assigned to these classes. Mr. Curran was not a mathematics teacher and did not attend any of the summer workshops prior to the start of school. He provided another adult presence in the class; however, he was not seen as a resource by the teachers. They were struggling to teach the INT curriculum using teaching methods that were less directive and less structured, just the opposite approach from what they thought was needed with these students. Their discontent grew out of their concern that the INT curriculum was not appropriate and was not working for these classes as they were constituted, and that the department's leaders ignored their concerns. This discontent grew over the course of the year.

Public and Political Support

Late in the school year administrators and teachers met with two groups of parents concerned about aspects of the mathematics program. This vignette, constructed from interviews, and from field notes taken during these two meetings, illustrates some of the pressures that have had profound influence on the evolution of the Mountainview mathematics program through its first three years.

Vignette 4: "One-Way Dialogues"

> *The classroom/conference room off the library provided a neutral setting for these gatherings. Cordial conversations occurring in small groups around the room were interrupted about five minutes beyond the scheduled 1:30 PM starting time when the principal, Mr. Danvers, asked everyone to take seats. The student desks were arranged in a circle large enough to accommodate the 26 people present.*
>
> *Mr. Danvers had called this meeting in response to the flood of complaints that he had been fielding since the mathematics department announced its plans for pre-calculus next year. Students from the six sections of HI-Five II, who would have completed two-and-a-half years of INT, are to be combined with students from the ten sections of Intermediate Algebra/Trig in next year's pre-calculus classes.*

Each of the parents—most of those present at this afternoon meeting were women—have children in Intermediate Algebra/Trig this year. The first one to speak, turning to acknowledge the parents seated to her left and right, said, "We want to know if there will be a traditional approach for kids with a traditional learning style." Several of those seated around her took their turns elaborating. "The trust level is just not there with kids who thought they were going to have it the traditional way. It's a question of learning styles." "We all know that different students learn on different tracks." "We ought to be able to choose the traditional grading system, too." "Will we be able to choose the teacher?"

It seems that two of the three teachers assigned to teach these classes next year, teacher-leader Larry Conrad and first-year teacher Mary Santoro, are perceived by the parents in this group as being "interactive," while the other, Dave Owens, is seen as being "traditional." All three were seated around the circle. Mr. Danvers looked confidently at the parents seated across the circle from him and said, "I guarantee, as best I can, that the kids will get their choice." Carol Jennings, the department coordinator who has been the lightning rod for all of the turmoil surrounding the mathematics program at Mountainview, sat quietly in the midst of the parent group and listened intently to those around her.

Two students were present at the meeting. One had been in INT I as a freshman, but had transferred to the traditional program, where he had completed Geometry and now Intermediate Algebra/Trig. He changed the tenor of the meeting as he made his feelings about the prospect of taking this "combined" pre-calculus course quite clear to the adults in attendance:

> *I've been in both kinds of classes, and INT is insulting. It has stupid names like "Hi-Five" and the units have stupid names like "Pig." There is no book, and the grading is subjective and arbitrary. There ought to be a totally traditional class, with a book and regular grading.*

Several other parents took this opportunity to speak up. One noted that she was made to feel as though it was a poor choice to want the traditional approach for her child. Others nodded in agreement. A second parent complained about the lack of computation and skill development, given the need to do well on standardized tests. One of the guidance counselors in attendance tried to explain that standardized tests don't measure everything taught in the INT program, but she was interrupted by comments about how the classes were being taught. "In Hi-Five it takes two hours to get a definition that you can get by looking it up in the book." "The methodology seems to be giving kids an alternative way to do math problems rather than teaching them math. It's real inefficient." "Teachers are facilitating rather than teaching." "If a student can move twice as fast as the one sitting next to him, what's the benefit?"

Carol Jennings had been convening and running these meetings since the school opened and the parents all knew who she was and where she stood. In fact, they had asked that she not attend this meeting. The principal thought she should be there, but took charge of the meeting in her stead. It was not until the meeting was almost over that she spoke for the first time. She tried to describe how subjective the so-called "objective" grading system they all wanted could be. As many of the parents shook their heads, sighed or threw their hands up in disgust, the first speaker of the day turned to the principal and, speaking sternly, asked, "If we don't want our kids to be guinea pigs for the program, whether it works or not, will we have a choice?"

Mr. Danvers signaled the end of the meeting by rising from his seat, walking across the room to the speaker, handing her a pad of paper, and reiterating for the group, "I am committed to giving you a choice. Sign your names and phone numbers and I will call each of you personally when we've made a decision about the choice of classes."

A new set of parents entered the room as soon as they saw, through the glass wall separating the meeting room from the main library, that the first session was over. All of the administrators remained, as did Carol Jennings and Mary Santoro. Larry Conrad and Dave Owens left, replaced by Sandy Jansen and six other members of the mathematics department. One of the few male parents in attendance set the tone for the second meeting when he angrily introduced himself to the group: "I'm an engineer who has a kid who has wasted two years in Hi-Five, and I'm fighting like hell to get him into Algebra I."

Mr. Danvers had been listening to complaints about the mathematics program since he took over the school in its second year. He decided to spread the word to parents that there would be an open meeting immediately after the first meeting to air these more general complaints, voiced primarily by parents of students about to enter Mountainview. The difference between this meeting and those that had been held frequently in the past (but not yet this year) was that he had called it, and he would be sure one of his administrators would run it.

Ms. Davis, one of the assistant principals, chaired this meeting. Afterward, she traced the origins of the discontent evident at these gatherings.

> *We have a pretty involved community out there. I think a lot of the controversy came with the fact that the kids didn't have a book, that parents couldn't help them with their homework, that [their children would] go back saying, "My teacher won't help me," because the teacher wouldn't tell them.*

While determined to "do the right thing for our kids in our community," she had grown "weary" of the controversy surrounding the mathematics department's program.

Mr. Newman, the Counseling Director who was also present at these parent meetings, stated his frustration more bluntly: "This math stuff has been sticking in our sides for a lot of years." When asked what portion of the school's parents were exerting the pressure everyone involved was feeling, and why they were exerting it, he made several points.

> *I think it's a small, vocal minority. The rest of the community trusts that we're professional educators, and they're trusting the care of their children in math classes. This is a small, vocal minority, but they're also in many instances the most active parents, the most affluent parents. They really do feel like they expect more than they get. I think their style is to be upper management, and that they know what's best. They will exert their influence. They have a long history of exerting their influence and getting the things the way they want.*

Another of the 35 attendees at the second, open meeting, who introduced herself to the others as a "concerned" parent, summed up her reason for coming when she said, "INT causes frustration for kids, and the approach causes frustration even in traditional classes, so we want a choice for those kids who need a traditional approach." She turned to Terri Thompson, who was one of the six mathematics teachers new to the school this year. Terry had taught mathematics for several years and was thought of by many parents as being traditional. The parent said to her, "If I had a child in your class I'd be comfortable." A few minutes later, however, Terri was grilled by another parent about how she grades the POWs she assigns in her Algebra I classes. The parent was visibly annoyed, and made a note on her legal pad, when Terri described that effort counted for one-third of the grade.

When teacher-leader Sandy Jansen spoke for the first time, trying to outline some of the strengths of the innovations they had made, she was interrupted by the comment "We aren't here to debate the merits of the program. We just want to be sure that there will be a choice." Mr. Danvers promised there would be. As the meeting described by Counseling Director Newman as a "one-way dialogue" adjourned, Carol Jennings, Sandy Jansen, and Mary Santoro met at the doorway, exchanged glances, and left together.

Discussion. Despite conducting a series of meetings with parents, producing and distributing information booklets, and testing students (with encouraging results), the first two years had been contentious ones for the mathematics department and, in particular, for Carol Jennings. Parents complained—to the teachers, to administrators in the building and at the district office—that their children were not being well-served by the new approaches being used. Providing the choice of either interactive or traditional programs had, during this third year, achieved the result desired by many, that of reducing the complaints. However, word of the plan to mix students in precalculus had caused a flare-up. Issues that had never been resolved returned to the surface, and the principal called a pair of meetings to put out the latest fire.

These parents did not trust the mathematics department to provide the choice they had been promised, and the precalculus decision further fueled that distrust. In fact, the classes in the traditional sequence were beginning to look less and less traditional; the interactive "approach," as the parents called it, was bleeding across the boundary between the two programs.

The principal and his administrative team tried to reassure these parents that those students who learned better in more traditional classes would, indeed, have a choice. True to his word, the principal followed up with each of the attendees. His letter to them stressed that the pre-calculus course would prepare students for calculus; that it would include homework from the text that would provide guided practice for students; that instruction would "blend the best practices from the past, present, and future"; and that teachers would be available to help students, both during the school day and before and after school. He also asked parents for support during periods of student frustration caused by "plateaus of learning" that they would all experience from time to time (Letter to Parents, 6/9/93).

The preceding vignettes portray groups talking past each other, unable to communicate because of vastly different conceptions of the issues at the heart of the reform effort being undertaken by the Mountainview mathematics department. The concerns expressed by parents actually mirrored those of the disaffected teachers within the department. After three years, during which time enormous effort had gone into professional support for faculty and education of the community, the root issues remained bones of contention.

The breakdown in communication prevented the department from working through the real and serious issues being raised. As a result, some teachers of traditional classes did not feel valued, and some parents who chose the traditional sequence felt as though they made the wrong choice. Her lead role in the development of district-wide proficiencies and assessments, in conducting workshops on curriculum materials like Visual Math or teaching strategies such as cooperative learning, have given Carol Jennings a high profile in the school district. This has placed her at the center of the increasingly rancorous debate over the changes she has advocated. As described above, the small but vocal group of angry parents gave her no respect. She and her principal disagreed about his decision to provide these parents with the choice they demanded. The support she did receive was equivocal:

> Algebra is the gateway to college. I've got to trust Carol when she says that most of what kids learn in Algebra I they forget and need to re-learn in Algebra II/Trig. She says that it really restricts kids from going on in math, and that if we took away that one restriction we'd find kids being far more successful. The notion that all kids can handle higher level math, I think it's a neat philosophy. I still believe that there's a need for some kind of basic skills math, because our special ed. kids have learned to let other people do the work for them. The interactive learning situation is perfect for them; they don't have to do a damn thing (Mr. Newman, Counselling Director, 6/10/93).

The administrators did not really trust her, in part because what she was saying was so different from what these experienced administrators believed to be the case.

Drawn away from the building by her district responsibilities, Carol relied on her instructional leaders to provide day-to-day support for the staff. Sandy and Larry could not have been more knowledgeable or committed to the program. However, they were—even with a period per day of release time—teaching four classes of their own. And, as Sandy related in a hallway conversation, she felt ill-equipped to divide her attention between her students and the adults in her department (Field Notes, 11/30/92).

Administrative Roles

In a district where site-based decision making had been in place for some time, it was up to the administrators at the school to handle the demands of dissatisfied parents. Those administrators, from the principal on down, acknowledged that skilled teachers might be able to make interactive classes work for most kids, but they were not completely convinced. They were convinced that their staff included teachers who were not skilled enough to do this, even if it were possible. Administrative frustration with the mathematics department was apparent in statements such as the one made by the principal, who told an interviewer that one of the problems he saw with the mathematics program was the "arrogance" of mathematics teachers who were unwilling to listen to the concerns of parents.

The district's Director of Program Development, a mathematics educator himself who was familiar with the work going on at Mountainview, summed up the dilemma faced by school and district policy makers, and how it was handled:

> There is a segment of the parent community that is not going to accept anything but what they see as a very traditional approach to teaching math. So the dilemma you face is, what do you do with these people? You can try to win some of them over, and they've really worked hard at that. But there's still a group that's left. So what do you do? Do you tell them to go someplace else? They don't really like this because it takes the kid out of the social setting of the neighborhood. You're put in the position of forcing something on these people they don't want. So because of that, the principal, who is not what I would call an innovator, took the position of, "I'm going to provide some options that meet different people's needs" (8/17/93).

The decision to run dual mathematics sequences had one unintended consequence that was of crucial importance. Because of its reputation as the "Ellis Island" of the district (Mr. Newman, 6/10/93), the school had a higher proportion of Pupil Service students than any other high school in the district. Neither mathematics sequence included a "general" or "remedial" mathematics course that would be the likely placement of such students. Most of these students were deemed not ready for algebra, which left them one choice for mathematics class: INT I. It is not surprising that Mark Monroe and Karen Barrow, who taught the classes with the resource teacher, and Carla Weiss, whose two INT I classes were quite large and contained a significant minority of Pupil Service students, were among the most skeptical about the interactive program.

IV. CONCLUSIONS AND IMPLICATIONS

Three years of hard work and struggle brought the Mountainview High School mathematics program to the point described in the preceding sections. This section will summarize what was different about mathematics teaching and learning at the school as a result of this hard work. It will also highlight and attempt to tie together some of the issues that have influenced the players at the school and are likely to continue to do so in the future.

What Has Changed at Mountainview High School?

Many of the students at the school take mathematics classes in which content is integrated and tied to real-life applications. They do mathematics "one problem at a time" (Lampert, 1991). They work in groups and present their results and difficulties to their classmates and their teacher. They regularly tackle extended problems and complete often lengthy write-ups of their work. They argue, question, seek justification, and determine correctness. They compile portfolios of their work, take matrix finals, do self-assessments, and negotiate with their teachers for their grades. Based on data collected by the school, these students tend to do well on standardized tests. They tend to continue their study of mathematics beyond the time required for graduation.

The remaining students take mathematics classes that have familiar names and use familiar-looking textbooks. However, none take general or remedial classes; no such classes are offered. These students in these courses use the most up-to-date texts available. They also do extended problems and write-ups. They also take matrix finals. And in order to graduate they are also being held to the new district proficiencies in mathematics.

Mathematics teachers at the school meet weekly in teams, by course, to plan instruction. They wrestle with the newest curriculum materials and a variety of assessment strategies in order to help their students meet school and district requirements. Some teachers are involved in professional activities outside the school. Some team-teach. Two teachers have been given release-time to provide the rest with professional support. The department's coordinator has moved the district in a direction that supports the mathematical goals of the school.

Visitors to the school during the 1992-93 school year saw dramatic differences in the ways in which mathematics was being taught and learned. These changes, however, had not come easily. The teachers in the department were deeply divided about fundamental issues of curriculum and pedagogy, and the breakdown in communication among members exacerbated these divisions. A small but powerful group of parents disagreed with many of the changes being attempted—disagreements that paralleled those expressed by some teachers—and put pressure on teachers, administrators and district supervisors. Those policy makers were caught between the department's efforts to change and parents' resistance to these changes. They made decisions that had the effect of compromising some of the goals of the mathematics program.

Conclusions

The issues that have shaped the development of the mathematics program at Mountainview, issues that manifested themselves in the disagreements described throughout this case study, can be tied together using the constructivist perspective on student learning that underlies most of the recommendations for reforming mathematics education, and which guided the writers of the interactive curriculum materials used at the school.

All actors in the school community construct their own reform. The so-called "constructivist perspective" is at the heart of efforts to develop the Mountainview mathematics program. There is no universal agreement among theorists about what constructivism is. The present discussion is based on the following interpretation of constructivism. The constructivist perspective asserts that students learn when, working alone and with others, they struggle to reconcile their current experiences with prior knowledge. This perspective acknowledges the active participation of individuals in their own learning. It also acknowledges the context in which this knowledge construction occurs. In fact, part of what is constructed by the individuals who comprise the learning community is the set of norms and expectations that frame the work of the community's members. This is a particularly important aspect of learning in the social context of school.

Central to the construction of knowledge are problem situations that produce the disequilibrium necessary for knowledge growth. The interactive curriculum materials adopted by Mountainview High School provide students with mathematical problem situations. The pedagogy employed by the school's mathematics teachers also present "problems" for the students; they are asked to work together, understand why, and communicate that understanding to their peers and their teachers. And they are asked to do this using new technological tools and without the familiar textbooks.

However, problem situations abounded at all levels and for all actors at the school. For example, teachers of interactive classes had to struggle with curriculum materials that were organized around multi-faceted mathematical problems rather than hierarchically-organized topics, that included some unfamiliar mathematical content, and that played down some familiar features such as skill practice that many teachers valued. Unlike most textbooks, the materials also specified that teachers use new and unfamiliar instruction and assessment strategies. Teachers were asked to construct new understandings of both curriculum and their roles in their classrooms.

The school's reputation in the district as an alternative for unsuccessful students, coupled with the *de facto* tracking of a disproportionate number of those students into INT classes, contributed to the difficulties for these teachers. Several teachers believed these materials actually prevented them from meeting the needs of their students. They interpreted the constructivist assertion that "students construct their own understanding" to mean "students need to be left alone to construct understanding." Rather than developing an altered, but active, role in their students' learning, these teachers merely diminished their traditional role. They struggled, alone and in teams, within a departmental structure headed by people who had been struggling with these problems themselves for several years; the leaders were, despite constraints that seemed insurmountable to some, committed to the entire package of reforms.

Problems for students in traditional classes included dealing with assessment approaches that were not well-aligned with the curriculum materials they were using. For example, matrix finals consisting of a few problems that span the content are hard to reconcile with topic-by-topic content coverage.

Teachers of traditional classes grappled with a different set of problems. They had to incorporate problems of the week, matrix finals, portfolio assessments, and other features of the interactive program into traditional classes. They had to deal with the sense that their efforts were not the priority of a department whose leaders' efforts were directed elsewhere. The frustration of their students with innovations they thought they had avoided by choosing traditional classes fueled some teachers' reservations about the reforms.

Some parents perceived two problems. The first was that the changes being made by the mathematics department frustrated their children and made it difficult for these parents to help in familiar ways. The interactive program, and those features of that program that had made their way into traditional classes, were not aligned with the learning styles of their children, or with what they understood to be the way school mathematics worked.

The second problem for some parents was that efforts to group students heterogeneously into classes that had names that had no meaning could not possibly be preparing their students for acceptance to competitive colleges. The advantages that normally accrue to students in the top tracks of traditional mathematics programs were being stripped away by these reforms. Their solution was to demand to be able to choose for their students a game with familiar rules, but by incorporating interactive features in traditional classes the department was seen to be undermining their ability to make that choice.

Administrators were presented with a problem every time one of these parents picked up the telephone. The goals of the mathematics department were, at the deepest level, not well understood by these policy makers, so it was difficult for them to justify the actions of the department to parents. Compromise solutions were the only ways for them to quell the controversy fueled by department leaders' commitment to the total package of reforms. These solutions had unintended results, such as undermining efforts to group students heterogeneously.

Larry Conrad was referring to learning new mathematics when he said that the work of teachers in a context of change is to "construct for ourselves where we are going." His comments can be taken more generally. To teach from a constructivist perspective, teachers must themselves learn very different conceptions of their work. Students will be asked to learn as much about what is expected of them as about mathematics content itself, what Sandy Jansen described as "knowing what to do when they don't know what to do." Their teachers must learn how to negotiate new expectations, particularly with students who have been in traditional classrooms for years.

Administrators have to learn how to fit these classrooms into their school's structure, so they can make knowledgeable placement decisions and respond knowledgeably and persuasively to parents. Those parents need to learn new ways to support their children as they struggle to understand new material. Some of this material might even be unfamiliar to parents. Parents need to learn how new approaches used by teachers might help their children learn mathematics in ways that will prepare them for future classes, college, or work.

Some believe "facilitating" is not "teaching". Several teachers described their struggle as learning to teach less and facilitate more. The parents who complained most loudly echoed this distinction. The belief that facilitating is a less involved classroom role and is not teaching made it much more difficult for teachers to accept that role. After all, they are paid to teach students; if facilitating is not teaching, then they are not doing their jobs. To Sandy Jansen this dichotomy is false. She saw her facilitator role as being much more active, much more involved with her students' thinking, than her old role as a dispenser of information.

Some see alternative assessment as subjective. Most of the grading schemes employed by the mathematics department were described, by teachers, students, parents, and administrators, as being "subjective." This contrasts with traditional forms of grading, using numerically graded quizzes and tests and final grades based on well-understood percentages, which were seen as "objective." Moreover, these subjective measures were seen to be of much less value by many. After all, these assessment schemes stressed process as much as product, which for angry parents meant there was no emphasis on right answers. Carol Jennings and others attempted to show how subjective traditional assessment techniques could be. They also tried to convince others that the alternatives they proposed and used provided so much more information about what students actually know and can do. Yet, even though teachers at the school had gathered an enormous amount of data in the form of the actual work of students, administrators searched for an "instrument" that would tell them if the reforms worked.

Some teachers believe the reforms offer less concern and support for students. Terri Thompson and Mark Monroe voiced the concern of some that students were never mentioned in the interactive program. They and others felt unable to support students when, for example, they were unable to reward them for trying. For these teachers it was particularly difficult to engage students in the struggle to attain high standards of achievement when those students were not normally motivated or who did not normally do well. It was ironic that a program viewed by visitors as an accelerated curriculum, one that held all students to high standards, would be seen by counselors as the only choice for students deemed not ready for algebra. The unintended result was that more of what some of these teachers saw as the wrong kind of students were placed in interactive classes, and traditional classes became the choice for college-bound students.

Some teachers, parents and policymakers see innovation as controversial and disruptive. The school that had opened with the goal being different was, by the end of its third year, very much like a traditional high school. In a district that allowed students to choose their high school, and in which several very highly-regarded traditional schools already existed, this school was nonetheless expected to provide the choice of a traditional high school experience for its local students. It is ironic that the most truly innovative program at a school that opened with the goal of being innovative generated the most controversy.

Some see the difference in pedagogy as merely a matter of "style". The phrases "teaching style" and "learning style" were used by many in the continuing debate about the direction of the mathematics department. Pedagogical decisions such as the use of cooperative groups or block assessment were referred to as differences in teaching style. Dissatisfied parents complained about the mismatch between the approach used in interactive classes and the learning styles of their children.

Style is defined as "the way in which something is said or done, as distinguished from its substance" (American Heritage Dictionary, 1981). Are the differences between interactive classes and more familiar "traditional" ones merely matters of style? Is the reason for having two programs simply to get to the same place via different routes, as was described by some teachers, a few students, and most administrators? Do some students really learn mathematics better in classrooms where they are told, clearly and unambiguously, what to do and how and when to do it? Is the decision of which sequence to take merely one of matching teaching style with learning style?

The most angry parents clearly agreed with this view. Furthermore, this view seemed so obvious to them that any attempt to justify the interactive approach for all students—including evidence from the most valued source, standardized tests, that the program worked for a wide variety of students—was met with derision.

Those most committed to the interactive program at Mountainview did not agree that the interactive program offered merely another style of mathematics class. The two instructional leaders, for example, could not have had more different teaching styles. One described herself as a "control freak" while the other admitted that he struggled with letting his classes go off on their own ideas too long. Yet their students' mathematical experiences were of a type. Their students were expected to work hard, to achieve, to understand why, to cooperate, to be critical, to justify and expect justification from others. And they had good personal relationships with their students. Ms. Jansen was "mom"; Mr. Conrad was "coach."

On the other hand, their students' mathematical experiences were quite different from the experiences of students in traditional classes. Even though teachers like Ms. Thompson and award-winning Mr. Monroe were very close to their students, and even though their personal styles were more similar to Mr. Conrad's and Ms. Jansen's than they were different, the students in their traditional classes had a much more traditional mathematics experience. For example, they relied on their teachers for more and different kinds of help and support.

Relegating the profound differences between the two programs offered by the department to mere differences in "style" made it easier for all constituents to ignore the fundamentally different beliefs about mathematics, about learning, about teaching, and about students, upon which the programs were based.

Some teachers find it difficult to develop new ways to judge their own efficacy. All teachers need to feel efficacious, or effective, in their work. Smith (1993) has argued that current reform efforts, driven in part by constructivist conceptions of learning, undermine one of the primary traditional sources of efficacy for teachers: sharing their mathematics knowledge with students by telling. He asserts, however, that these reform efforts also provide new sources for teachers to judge their effectiveness.

> Though constructivism shifts the spotlight from teacher talk to student sense-making, the teacher is not a by-stander in the learning process. A central issue in effective constructivist mathematics teaching involves knowing how to shape the sense-making experiences of students. Choices are unavoidable; the issue is making thoughtful and defensible ones. Though these choices place a burden on teachers normally assumed by textbook writers, textbook selection committees and teacher educators, they also offer an opening to feel effective when students' learning is positively affected (Smith, 1993, 14).

The degree to which individual teachers at Mountainview identified themselves as "interactive" or "traditional" seems related to their sources of efficacy in the classroom. At one extreme, Sandy Jansen and Larry Conrad drew great strength from students' ideas. They were always being impressed as they listened to their students. They helped their students by asking questions and then getting out of the way, and the interactive program provided a supportive structure (and lots of interesting questions). At the other extreme, Terri Thompson and Mark Monroe found themselves unable to help their students. They found it difficult to reduce student frustration and make their classrooms comfortable places for their students. They found that the interactive program's structure actually increased students' frustration, and it stifled teachers' ability to deal with this.

The support structure provided by the department—weekly meetings to discuss mathematics and plan the mechanics of classes—was helpful to some, but not to others. Mary Santoro was excited about the interactive program and found the support structure helpful. She felt she had done a good job when she didn't say much, when her students took off on a mathematical discussion, when they applied what they had learned in new situations.

On the other hand, Carla Weiss found that her students "perform beautifully when I put them in rows. They can work by themselves and listen to me." She struggled to guide her students, to get her classes to be more "teacher-directed." It was not helpful for her to have meetings in which someone "flipped through the book with her." She needed to be helped with answers to the question "How do you keep kids on task?"

These two young teachers drew on quite different sources for their senses of efficacy. One latched onto the interactive program, and the other rejected it. The same support structure was available to each, but it was "support" for only one.

Future Prospects

As the next school year began, Sandy Jansen had left the department to go to graduate school. Terri Thompson had transferred to a middle school in the district, and interactive classes were being taught only by some members of the department. Carol Jennings had given up her position as department coordinator, but she remained in charge of the interactive sequence, and returned to the classroom. She was later appointed to a task force that would write state-wide mathematics standards. Larry Conrad and Mary Santoro became involved in a national program to develop and test portfolio assessments.

The department's goals became, more generally, to "implement the NCTM *Standards*" and to ensure that all students meet the district's proficiencies, regardless of the sequence of courses they choose. The two-tiered interactive sequence was condensed to one; Hi-Five I became the first course, and summer classes were offered to students from other middle schools who wanted to enroll in this sequence. The department decided to cut down on the number of visitors, but the program's reputation continued to grow across the region as Carol and Larry Conrad turned their attention to helping other schools adopt the interactive curriculum.

Carol Jennings, whose vision inspired the reform effort at the school, had hoped that the interactive program would become *the* mathematics program. It is not clear how that will occur if the perception remains that the school must provide a choice to its "clients." The pressure to retain that choice remains, as does the search by administrators at the school and district level for data that could be used to relieve those pressures. However, Carol and her colleagues have been able to establish the interactive sequence as a viable choice for a wide variety of students. They have succeeded in influencing the district's policies in ways that support their goals. They have developed and put into place a variety of alternate assessment strategies which are seen around the country as exemplary ways to determine what students know and are able to do. As a result of extraordinary and difficult work, a majority of the students who attend Mountainview High School have a mathematics experience that is fundamentally, and irrevocably, changed.

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APPENDIX A
MOUNTAINVIEW HIGH SCHOOL ETHNIC/RACIAL DATA 1992-93

Table A-1: Overall School Ethnic Data

	Males		Females	
	Number	Percent	Number	Percent
American Indian or Alaskan Native	4	0.47	2	0.24
Asian or Pacific Islander	25	2.91	26	3.06
Black, NOT of Hispanic Origin	55	6.4	44	5.18
White, NOT of Hispanic Origin	747	86.9	751	88.5
Hispanic	29	3.37	26	3.06
Totals:	860		849	
Total Enrollment:	1,709			

Table A-2: Interactive Sequence Ethnic Data

	Males		Females	
	Number	Percent	Number	Percent
American Indian or Alaskan Native	2	.49	0	0
Asian or Pacific Islander	7	1.72	7	1.78
Black, NOT of Hispanic Origin	25	6.15	18	4.58
White, NOT of Hispanic Origin	355	87.4	357	90.8
Hispanic	17	4.19	11	2.80
Totals:	406		393	
Interactive Sequence Enrollment:	799			

Table A-3: Interactive Sequence Students, By Grade

	Grade 9	Grade 10	Grade 11	Grade 12
Males	228	125	48	5
Females	215	105	69	4
Total	443	230	117	9

APPENDIX B

MOUNTAINVIEW HIGH SCHOOL ACHIEVEMENT DATA

Table B-1: Teacher Reports of Student Proficiency Levels

		Percent of Students in Grade			
Mathematics Proficiencies		9	10	11	12
#1: Numbers/Number Relationships	Below Basic	6.3	11.2	2.5	0
	Basic	25.5	29.9	25.1	20.3
	Proficient	51.9	45.0	51.4	42.0
	Advanced	16.3	13.9	21.0	37.7
	Below Basic	23.7	20.1	7.5	1.4
#2: Geometry/Measurement	Basic	29.8	41.3	29.5	23.2
	Proficient	38.6	31.0	51.4	40.6
	Advanced	7.9	7.7	11.6	34.8
	Below Basic	8.1	15.0	17.2	7.2
#3: Probability/Statistics	Basic	31.6	47.6	34.2	44.9
	Proficient	51.3	33.8	43.6	44.9
	Advanced	9.0	3.6	5.0	3.0
	Below Basic	12.9	29.9	8.5	1.4
#4: Patterns/Functions	Basic	35.5	35.7	25.1	20.3
	Proficient	33.4	28.7	46.7	43.5
	Advanced	18.2	5.7	19.7	34.8
	Below Basic	21.2	20.9	7.8	0
#5: Algebra	Basic	38.1	38.5	29.8	21.7
	Proficient	29.3	33.1	50.2	44.9
	Advanced	11.4	7.5	12.2	33.3

Table B-2: SAT Comparison Data 1991-92
(Excerpt from information sheet given to parents)

Class	Number of Students	Average Raw Score October 1991	Average Raw Score May 1992
INT I	207	6.74	9.66
Alg I	83	6.91	8.16
INT II	31	14.10	18.52
Geometry	131	12.82	17.20
Int. Alg/Trig	45	18.87	21.47

First, we compared each class with itself to see if growth had taken place. The increase in class averages from fall to spring for all grade levels were significant at the $p = .05$ level. From this, we concluded that our students have grown mathematically in all of our classes. At the more restrictive level of $p = .025$, only the gains of the Algebra I classes became nonsignificant.

Comparing the average gain of all the students in [INT I] to the average gain of all the students in Algebra I, there was a significant difference at the $p = .025$ level with the interactive students having made significantly higher gains than the Algebra I students. In the fall, Algebra I students and interactive students had similar average raw scores. In the spring average scores were higher for the interactive students. When we consider that the interactive classes were heterogeneously grouped ... and that the Algebra I classes are more homogeneously grouped, this statistic ... became the most impressive of our study.

Table B-3: SAT Raw Score Comparison Data 1992-93
(Excerpt from information sheet given to parents)

Course		Spring '92	Spring '93	Course		Spring '92	Spring '93
Alg I	*mean*	5.23	13.26	High Five 2	*mean*	8.92	15.37
($N = 48$)	*sd*	5.76	8.60	($N = 86$)	*sd*	7.29	10.42
High Five I	*mean*	5.69	13.35	Alg 2/Trig	*mean*	13.18	22.47
($N = 243$)	*sd*	6.76	9.80	($N = 97$)	*sd*	8.16	9.59
Geom	*mean*	7.60	15.71	IMP 3	*mean*	14.51	24.10
($N = 42$)	*sd*	7.00	9.46	($N = 33$)	*sd*	7.09	9.17

APPENDIX C

SELECTED TEACHER ASSESSMENT MATERIALS

Sandy Jansen's Block Assessment Codes

Block Assessment

Block I: Attitude

Attitude positive
Behaves well
Group cooperation and participation good (doesn't over-participate or under-participate)
Helps others when they need it
Listens well to the teacher and other students
Uses the group to learn and grow in math
Volunteers ideas and solutions in large group discussions
EQ Willingness to explore and Question
CJ Conjecturing and testing conjectures

Innocent of the following:

1. Excessive talking and noise making
2. Time off task or inattentiveness
3. Abuse or misuse of math manipulatives
4. Tardiness
5. Interfering with other students ability to learn
6. Coming to class unprepared

Block II: Content

Q1uality problem presentation (solved or unsolved)
Q2uality problem extensions
Q3uality of work is high
Connections of concepts in problems
Concepts grasped
Demonstrates good mathematical communication
Estimation used in determining reasonableness of answers
Insight or creativity
Looks for more than one path to solutions
Much improvement as a problem solver
Not willing to give up on hard problems
Questioning constructively
Reasoning mathematically
Steady, dependable worker
Working for understanding

Block III: Excellence

Impress the instructor by:
Sharing special mathematical insight or creativity
Obvious extra effort in and outside of class
Making connections, both mathematical and interdisciplinary
Exceptionally positive attitude

Larry Conrad's Student Self-Assessment Form

Block Self Assessment

For each characteristic in the attitude block and the content block, place an X on the line of continuum that indicates the way you have chosen to participate during the fourth quarter. Then indicate the overall level you've fulfilled each block. If you have fulfilled the Dedicated to Excellence block, write a description of how you have fulfilled this block and attach any necessary papers. **Include any papers or examples to help support your chosen grade.**

Block I: Attitude	**ALWAYS** **NEVER**
Components of a positive attitude in math class	o-----------------o
Behaves well	o-----------------o
Group cooperation and participation good (doesn't over-participate or under-participate)	o-----------------o
Helps others when they need it	o-----------------o
Listens well to other people in the classroom	o-----------------o
Uses the group to learn and grow in math	o-----------------o
Volunteers ideas and solutions in large group discussions	o-----------------o
SR Showing Respect for every student's right to learn	o-----------------o
EQ Willingness to explore and Question	o-----------------o
CJ Conjecturing and testing conjectures	o-----------------o
1. Interfering with communication	o-----------------o
2. Time off task or inattentiveness	o-----------------o
3. Abuse or misuse of math manipulatives	o-----------------o
4. Excessive tardiness or poor attendance	o-----------------o
5. Interfering with other students ability to learn	o-----------------o
6. Coming to class unprepared (includes having necessary materials and taking care of physical needs i. e. rest room and drinking, outside of class.)	o-----------------o
100% OVERALL BLOCK 0%	
Number of POW's due during fourth quarter.	
Number of POW's attempted and handed in.	
Quality of work on POW's. (circle one)	Poor Good Excellent
Number of homework assignments completed	
Number of -'s	
Number of √'s	
Number of +'s	
Number of assessments completed.	

Explain how the above information demonstrates how well you have completed this block.

Block II: Content	**ALWAYS**
Q1uality problem presentation (solved or unsolved)	o - - - - - - - - - - - - - - - - -o
Q2uality problem extensions	o - - - - - - - - - - - - - - - - -o
Q3uality of work is high	o - - - - - - - - - - - - - - - - -o
Working for understanding	o - - - - - - - - - - - - - - - - -o
Looks for more than one solution and/or more than one process to a single solution.	o - - - - - - - - - - - - - - - - -o
Concept grasped	o - - - - - - - - - - - - - - - - -o
Demonstrates good mathematical communication	o - - - - - - - - - - - - - - - - -o
Estimation used in determining reasonableness of answers	o - - - - - - - - - - - - - - - - -o
Insight or creativity	o - - - - - - - - - - - - - - - - -o
Questioning constructively	o - - - - - - - - - - - - - - - - -o
Much improvement as a problem solver	o - - - - - - - - - - - - - - - - -o
Not willing to give up on hard problems, Persistence	o - - - - - - - - - - - - - - - - -o
Reasoning mathematically	o - - - - - - - - - - - - - - - - -o
Steady, dependable worker	o - - - - - - - - - - - - - - - - -o
100% OVERALL BLOCK 0%	

Discuss what you learned on each of the POW's you have completed.

Discuss the concepts (from this unit) in which you demonstrated understanding, include (in your discussion) any assessments you have completed.

Block III: Dedication to Excellence

Describe specific activities, discussions, projects, connections, or any other way that you have fulfilled this block. (Attach paper if necessary.)

100% OVERALL BLOCK 0%	

A - Means I have successfully completed all three blocks
B - Means I have successfully completed two blocks
C - Means I have successfully completed one block
I - Means I am still in the process of completing at least one block

After completing the self-evaluation, I can with confidence and self-respect say that based on the standards discussed in this class, my performance for the 3rd quarter has been ...

A B C I

Signature____

Do Not Write Below This Line

After completing your evaluation, I can with confidence and self-respect say that based on the standards discussed in this class, your performance for the 3rd quarter has been ...

○ Reached Consensus **Signature** ____________________________
A B C I

CASE STUDY OF FORT SHERIDAN MIDDLE SCHOOL SCIENCE DEPARTMENT

KATHLEEN DAVIS
CURRICULUM REFORM PROJECT
UNIVERSITY OF COLORADO

1995

This paper was prepared for the Curriculum Reform Project, a study of curriculum change in mathematics, science and critical thinking which is funded by a grant from the U.S. Department of Education's Office of Educational Research and Improvement (OERI Grant #R91182001). The opinions expressed herein are those of the author and the participants in this study.

FOREWORD

When faced with a challenge, a detailed story of someone else's experience in a similar situation generally is of strong interest. In reading someone else's story--be it political history, a chronicle of dealing with a family tragedy, or the story of a major business success--we do not expect to find a formula to apply directly to our own situation; instead we hope to find insight and inspiration. Thus, the story contained in this report should be engaging to individuals committed to educational reform in a local school context. It is the story of one school--or department within a school--engaged in fundamental reform of education for its students.

Similarly, one should not expect to find in this case a model for a specific educational reform to initiate in another locality. Every context is different. Each local school and community culture has its distinctions, each individual's and group's educational goals have different shadings, each setting has its own history, and each school has unique constraints to making change.

Not only does one formula not fit all schools, there is no specific formula for a given school. A central message of our case studies is that educational reform is a long-term process for which there is no detailed road map. It is an uneven process with highs and lows, failures and successes, but gradual movement toward greater and more profound learning for students.

What we can expect to find in this story are insights about new teacher roles, how students go about learning with greater depth of understanding, the context in which such shifts can occur, the challenges that must be overcome to initiate these changes, and actions taken by various parties to keep the process of change moving forward. Reflecting on someone else's story can be helpful in the process of developing one's own plans, collaborating with others to move the process forward, and helping students take responsibility for learning.

The Research Project. The case study reported here is one of nine--three each in science, mathematics and higher order thinking across the disciplines--conducted as part of the Curriculum Reform Project. The cases were studies of individual schools--actually a department within a school in the case of science and mathematics--in the process of solidifying reform. Each was selected because it was a successful example of reform. A researcher spent 20 or more days at the site to learn what changes they were making, the barriers encountered, how they overcame these challenges, the nature of their successes and their hopes for the future.

Site Selection Criteria. Sites were sought which had initiated reforms consistent with those recommended by leading groups in the respective field, e.g., the Curriculum and Evaluation Standards for School Mathematics (Commission on Teaching Standards for School Mathematics). Final selections were based on program outcomes including student test scores, enrollments in subsequent elective courses in the given subject area, and professional judgments about the quality of the curriculum provided to students.

Site Selection Process. The search process began with the solicitation of nominations from researchers and knowledgeable practitioners across the U.S. Key people at the nominated schools were contacted by phone to get additional information and written exchange of information followed. Selection according to the above criteria resulted in schools spread across the country with considerable variation in location (e.g., urban vs. rural), economic level and ethnic makeup of the communities.

Research Methodology. In each case the researcher was immersed in the activities of the school and collected a wide range of information. Data included classroom observations, interviews with students, teachers and administrators, and a variety of documents from the site. The voluminous field notes and interview transcripts were analyzed and an interpretative report written.

Cross-site Analysis. A cross-site analysis of the nine cases was conducted to gain perspectives that extend across the sites. An individual case is rich in description and context but does not contain the depth of analysis that can come from looking across a number of cases. Thus, the reader is referred to the Project's cross-site analysis. Main points from this analysis to bear in mind while reading this one case, however, include the following:

- The reforms being sought are profound and demand major changes in teacher and student roles.
- The process for achieving such reforms is complex and demands a long period of time to attain.
- The schools in these cases have traveled a considerable distance on the road to reform but have not yet "arrived."

These cases are presented largely--though not exclusively--from the perspective of the teachers at the center of the cases. This perspective reflects the nature of the reforms and the way they have been initiated in each school. This perspective may be particularly important for initiating change. Our cross-site analysis shows that changes in teachers' values and beliefs--not just greater teaching skills and techniques--are central to reform. While changes in student roles and student work are the ultimate "bottom line," these teacher changes are an important intervening step.

We hope your reading of this case stimulates both interest and significant reflection about reform activities in your school.

Ronald D. Anderson
Director, Curriculum Reform Project
University of Colorado

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I. INTRODUCTION

Throughout the country, there are many efforts to bring varied forms of change to science education. Successful implementation, though hoped for, is not always guaranteed. Indeed there are many obstacles to change. Unfortunately educators are not yet fully knowledgeable of the critical approaches necessary for overcoming barriers.

This study describes the implementation of a middle school science reform curriculum. It is hoped that through such studies, science educators, policy makers, and program developers will have a better understanding of what is needed in order to successfully implement curricular reform in science education. The purpose of the analysis is to examine and describe the substance of the reform at this particular site, to describe the factors that have been critical to its implementation, and to discuss the dilemmas that have emerged as a result of the implementation process.

Data for this study was acquired through on-site visits at the school over a period of nine months. Data was collected primarily through 1) classroom observations, 2) faculty meetings, 3) interviews with the program developers, university site-coordinators, and support personnel, administrators, teachers, and students, 4) science curriculum materials, and 5) state and district documents that address the reform effort.

The Site

Fort Sheridan Middle School (FSMS) is situated on a military base (population of about 17,000) in the heart of an agricultural region and adjacent to a city with a population of about 22,000. Sitting in a FSMS classroom would seem to be like any other middle school classroom across the country except for the days when the thundering sounds from huge guns rumble and roll across the base and shake the walls and floors of the classrooms. Though disturbing and distracting to me, the visitor, the sounds appear to go unnoticed by the classroom teachers and students.

The school is part of a larger county-wide district that services about 7,200 students. The district is comprised of one senior high school, an alternative high school, two middle schools, and thirteen elementary schools. Fifty-six percent of the district's students have parents who are military personnel and who live on and/or work on the post. Because of the military population, the school has much greater ethnic diversity than one would expect in this geographic area: 52.1% of the students are white, 34.5% are African-American, 8.2% are Hispanic, 4.5% are Asian or Pacific Islander, and 0.7% are American Indian or Alaskan Native. The student population is 50.1% male and 49.9% female.

Fort Sheridan Middle School's student population of about 685 students is similar in race, ethnicity, and gender to that of the larger district; 48.3% are white, 37.8% are African-American, 8.5% are Hispanic, 4.4% are Asian or Pacific Islander, and 1.0% are American Indian or Alaskan Native. About 47% percent of the students are male and 53% of them are female. Many more of the students' parents, though, are military personnel (91.9%) as compared to students in the entire district and 87.8% of the students live on the military base. Many of these students' parents are enlisted personnel; officers' children are more likely to attend private schools or the city schools in the local university town.

Because of the high rate of military transfer, the school experiences a dramatic turnover in students each year. For example, the enrollment for the beginning of the 1992-93 school year was 606 students; 75 additional students were enrolled throughout the year and 162 students were dropped from the attendance records. The turnover, therefore, is approximately 39% during the school year and that figure does not include the additional 10% turnover that is estimated to take place over the summer.

Historical Context

The middle school science reform curriculum that is the focus of this study was part of a national curriculum development project. It was one of a group of middle school curricula which was funded by the National Science Foundation (NSF) in the late 1980's. Earlier in the decade, national funding for the development of innovative curricula had diminished, but with such publications as *A Nation at Risk* there was "external motivation" for national financial support to create reform curricula. Critical to the development of this middle school science reform curriculum was the funding made available by the NSF.

This reform curriculum was developed after an extensive review of the literature on science education, the middle school community, learning, cooperative learning, and constructivism. The goals of this curriculum focused specifically on the middle school child. This program sought to 1) develop students' understanding of basic concepts and skills related to science and technology, 2) increase the participation and success of under-represented populations (i.e. girls and minorities) in science classes, 3) improve students' understanding of how science and technology relate to their everyday lives, and 4) promote the development of higher-order thinking skills.

Features of the Science Reform Initiative. The curriculum incorporated several key features to achieve these goals. First, the curriculum integrated the earth, life, and physical sciences through units that are developed around conceptual themes including patterns of change, diversity, limits, and systems. Major concepts, such as patterns, cycles, trends, and correlations, were repeated, built upon, and linked together throughout the curriculum. In addition, students investigated the important elements of technology, such as the design process and also the risks, benefits, constraints, and the decision making surrounding a technological product or process.

The program utilized an instructional model based on constructivist learning theory in which students reflected on prior knowledge and participated in hands-on investigations to explore key concepts. Students were encouraged to ask questions, develop operational definitions, gather evidence, construct their own meanings and explanations for phenomena, and then test those explanations. Students used cooperative learning strategies to work together to solve problems, discuss ideas, and develop social skills.

The program also used other instructional approaches, including: hands-on investigations, creative writing, plays, research projects, and outdoor activities. It was the belief of program developers that the use of a variety of teaching and learning strategies, in addition to the constructivist instructional model, provided the classroom teacher with more opportunities to address the diverse learning styles of students.

The student textbook provided students with explanatory readings of science concepts and connections between classroom activities and ideas. Many of the readings provided students with a sense of the history and process of science and the dynamic nature of science. Investigations provided students with opportunities to participate in hands-on activities where they were encouraged to design their own procedures as they took part in the process of scientific inquiry and problem-solving and to communicate their scientific approaches to others.

The program encouraged students to become responsible for their own learning and to be actively engaged in the learning process, physically and mentally. Students could not be "passive participants" in the process of learning science and also be successful in this science program. Students were expected to draw on previously learned concepts and skills in order to design approaches and projects that would solve problems and answer questions.

District-wide Reforms. Before the 1990-91 school year and before implementing a new and innovative science curriculum, the Lincoln County School District had made the decision to adopt a middle school philosophy. As a result, Fort Sheridan Junior High School became Fort Sheridan Middle School. The change to a middle school created many other changes for the school: grade level changes, faculty changes, administrative changes, building renovation, and new program implementation.

Where, as a junior high school, Fort Sheridan once enrolled seventh, eighth, and ninth graders, it became a 6-7-8 building. Some of the junior high faculty moved to the high school and new faculty arrived from the elementary buildings; some junior high faculty remained at Fort Sheridan. Today, the middle school science faculty consists of seven teachers, two of whom moved over from the elementary schools.

During the three years that the science reform curriculum was field tested, all three of the sixth grade science teachers were elementary-based. One teacher was a 6th grade elementary science educator. Because she worked on the middle school task force, she was moved to the junior high the year before the change to serve as "Paul Revere;" she was sent "to beat the drum" for the middle school. A teacher new to the 6th grade science team came with experience as a secondary art and home economics teacher. Her science background was embedded in the science coursework required as part of her home economics major.

The remainder of the science faculty came with experience in secondary education. Two teachers previously taught science at Fort Sheridan Jr. High School, one taught life science and the other taught physical science. Another teacher was transferred from a science position at Lincoln City Junior High School, the district's other junior high school, and the seventh teacher came from the alternative high school. The school had a new principal with an elementary school background.

In preparation for middle school organizational and instructional changes, two additional wings and a new library were added to the 25 year-old building. Much of the construction was not completed by the opening of school in the fall of 1990 and many teachers taught in temporary structures until December of that year. Others continued to teach in their classrooms as work crews finished construction projects.

Curricular Change at Fort Sheridan Middle School. During the spring of 1990, with the implementation of the new middle school structure, the district administration sought a new science curriculum that would provide a vehicle for implementing the teaching approaches and strategies professed in the middle school philosophy:

> We were junior highs ... and we had the traditional, very segregated kind of approach of junior high science. Everything was separate - earth science, physical science - each year you got a different piece. There were several things wrong. One of the things ... was that it was not endearing kids to science ... when they got to high school, they were taking what was required and they were bailing out ...
>
> The other thing that was wrong ... was that there was a real ... willingness and acceptance of tracking ... [and] there's just no place for it ... we have an obligation to all the students ... The absolute commitment that these kids will be successful. That's what effective schools is all about ... if you're willing to be honest to the middle school format, you must give up ... tracking ... and that's what we aimed for..
>
> [T]hat's what made ... the change [to] the middle school--the problems with ... only serving some and the failure of these courses to have any meaning as the kid grew. [The schools] were just fertile soil for a change ... "

Just as the district was seeking a science program to facilitate the change to middle school, the local state university (SU) was seeking field test sites for the new middle school science curriculum described above. Upon hearing about the search for field test sites, the district administration then contacted the SU science site coordinator and arranged a meeting between the curriculum developers, the administration, and the science faculty of the district's Lincoln City Middle School (LCMS).

One concern raised repeatedly by a LCMS faculty member was that many years ago

> " ... there was another program that was introduced and piloted. At the end of the pilot ... the district refused to buy the concomitant material to support the effort and as a result, they were stuck back in the old stuff after they made all that effort to look at something new."

After a great deal of debate, the opportunity to field test the new curriculum was voted down by LCMS science faculty. The administration viewed the chance to field test the innovative program as important to facilitate change in the district and did not want to see it pass by. The opportunity to field test the new curriculum was then brought to the Fort Sheridan science faculty. For over two months, conversations were held about the field test of the new science program between university personnel and individual teachers. A meeting was finally held in May between the program developers, university site coordinator and graduate student staff, the FSMS science faculty, and district and school administrators. One teacher described the meeting after school as "pretty heated."

For some of the educators, the opportunity to pilot the science reform curriculum was something they had long awaited:

> For years I have dug for things ... 'Those of you who teach right from the book, is that good for kids?' You have to look at what's best for kids; I guess that's where I came to leap into [this program]. I had searched and hunted and begged and borrowed and stolen everything I could, to get some hands-on science. And [now] you don't have to go try to find all of it. And I was like, 'Oh, hallelujah!'"
>
> ... [W]e were just in the process of changing over to be a middle school, and it sounded like it fit exactly into the philosophy that we'd been going through and trying to come up with as we wanted to be a middle school.
>
> The idea of teaching science through a hands-on program and more from a ... process rather than a product sort of viewpoint ... that really made a lot of sense because the kids ... learn by doing.

This was a difficult time for this faculty, as not everybody supported the change. There were questions about student assessment. There were questions and concerns about how supposedly "non-science" people could teach the curriculum and how the program best utilized the expertise of those that had a science background. There were concerns that the administration would not adopt the published program at the end of the field test and that the field test would be more work for teachers. Some teachers felt that there was already a great deal of change taking place with the move to the middle school and that the field test would add to the stress.

Some science teachers felt that they were not being fully informed about the program, especially since they had not been given any books or teaching materials to look at. Others felt that they were not being given any choice; if one person wanted to do the program, they all had to do it. As one teacher explains it:

> There wasn't any information on the program ... They had no books for us to look at, they had nothing ... We were told we had to do it.

Another teacher states,

> ... [I]t was voluntary, then it wasn't.

Two faculty members were definitely not for the new program. "They wanted science as it was." "They felt that that wasn't what they wanted to do as teaching science." The principal, though, was supportive of the program. "It was a good opportunity ... to do something new." "He said, 'You know, we'd like a consensus.'" One teacher expressed the difficulty of the decision.

> I think probably the biggest, the hardest thing was going ... ahead and voting for what ... you thought was best for that and maybe stepping on some toes with people that ... you had a pretty good working relationship with ...

One of the dissenting faculty members quit because of the decision to field test the new curriculum. He basically said, "I'll not teach it" and left the district. It appeared that the remaining teachers' willingness to commit to trying the program and to work together was what allowed the reform to move forward. One teacher related the feelings of the remaining faculty: "I think we had the belief that this can work." The faculty held an element of "enthusiasm" and "hope."

Another teacher stated that:

> ... I think that most everybody ... that's here now is ... real open to giving it a try ... I think that what really helped keep it going is that everybody ... was really willing to give it a shot ... the people that we had here ... really made it work.

Most of the teachers that had come to the middle school did so because they wanted to change and "most of them were change people." Other teachers, though not in favor of it, reluctantly said, "I will give it a try." As the implementation process began, "the enthusiasm and success of the other teachers" and the support and "encouragement that they gave" was helpful in motivating those who were hesitant.

II. THE REFORM CURRICULUM IN PRACTICE

Fort Sheridan Middle School began field testing the science reform curriculum in the fall of 1990 and continued until the spring of 1993. The school district adopted the published curriculum for the 1993-94 school year. The following vignette is presented to provide a snapshot of a transformed science classroom at FSMS and to illustrate some teacher and student practices that conform with the innovative science curriculum.

> *Eric began class by taking roll and then referred to the day's activities that he had noted on the board. The students were working on an activity that they had been involved with for several days. The challenge was to make "waterfalls and falls." Water flowed from two plastic milk jugs, which were placed on a table, then through two plastic tubes and into a beaker that was placed on a chair and then through another plastic tube that emptied into a bucket that was on the floor. All the tubes were fixed with clamps to control the flow of water. The initial task was to control the flow of water as it moved through the system so that the water level was kept at 500 mls in the beaker. Once the team met that challenge, Eric put drops of food coloring in the jugs -red in one and yellow in the other. The new task was to keep the water level in the beaker at 500 mls and to keep the water color in the beaker an orange-tan color. Eric supplied a sample test-tube with the targeted color so the students could make a match.*
>
> *The students began right away. One group was very excited up about beginning the investigation. They quickly set up their system. The milk jugs were filled with water. They dropped two tubes into the bucket in order to fill them with water; they applied a clamp to the end of each tube and then dropped the unclamped ends into the jugs, then they opened the clamps until the beaker began to fill with water and then they closed the clamps. Next, they filled another tube and clamped it and ran it from the beaker to the bucket. All the students were engrossed in the process, except for one boy who looked at the operation once and then sat off by himself until the end of the class period.*
>
> *One of the groups was shorthanded as a team member was absent and there were only two students. "Can you help?" the boy asked me. Eric was there. "I don't see why not," he said. So I pitched in and worked one of the clamps going to the beaker. Though at times the strategies employed seemed haphazard: guessing-try this, try that, starting over with no stated plan, turning off one clamp and not the other, letting both tubes go full blast, getting one tube down to a trickle -the two seemed to get the hang of it and managed to keep the beaker at the required 500 mls and the color close to the test tube color. As they worked with the system, I asked the students to explain their strategies, but I was met with further directions, either to open or close the clamp, but no talk of why. This task required team work, following directions from one individual, and taking turns with giving directions.*

The floor, of course, was coated with water, and the mop and bucket were used heavily at the end of class. The boy who had sat off by himself put the mop and bucket away and got a sponge to wipe off his team's table. "If you want kids in rows, this program won't work for you," Eric said to me at the end of class.

The next day, Eric started class right on time. He pointed out the pre-class activities listed on the board:

Pre-class activities

1. *Have shoe box at your desk*
2. *Open books to p. 36*
3. *Have questions from yesterday out*

Also on the board were the day's activities:

Science Wednesday, Oct. 6

1. *Discuss 5, 6, 7, 8 from yesterday*
2. *Investigation: Heat in, Heat out*
    - *A. Instruction*
    - *B. Build Systems*

As the class reviewed the questions -"Identify the feedback and restoring mechanisms in the system ... "- they talked about the need to have equal input and output to maintain balance in a system, and the roles of feedback and restoring mechanisms. Eric and the students talked about the waterfall system and such systems as the heating system of a house and the role of the thermostat, the cooling system of a car and what happens when it overheats, and the maintenance of body temperature and what it means to "have a temperature."

Eric talked about car windows being rolled up and how heat could enter the car as sunlight came through the windows, but it could not escape. Today, the students needed to design a system for their shoe boxes so that it keeps the heat input and output in balance. Left in direct sunlight for 20 minutes, the temperature of the shoe box system should increase as little as possible. Eric said that they would build the systems today and then tomorrow they would test them if the weather cooperated.

The students were to use a shoe box with a thermometer inserted through a slit in the end of the box and leave the cover off. This was illustrated in their texts. Eric pointed out the additional materials that they could use, including various colors of construction paper, plastic wrap, and aluminum foil and where these materials were located in the room. He said that they could use other materials if they wanted.

Eric said that the teams should brainstorm ideas before they began to work; but only one group seemed to do this. They would write their plans tomorrow and, if the sun was out, the class would do the first test. If students didn't "know what to do" they should work with a teammate. Most students worked with their teams.

Many groups were using black paper, white paper and/or aluminum foil to line the inside of their shoe boxes. "Foil reflects the heat, right?" "Black paper absorbs the heat." "White paper reflects the heat." One group of girls had two small beakers in the box that they were going to fill with water to absorb some of the heat. They had also cut some windows in one side of the box to let more heat out. One group of girls was trying to figure out to what degree the white paper would reflect the light. By the end of class, the various teams were either finished or close to completion with their boxes.

Goals and Content

The content and structure of this program looked very different from traditional secondary science education. Gone were the neat rows of students quietly working at their desks. Absent were the lists of vocabulary words and the emphasis on facts (i.e., learning the parts of the flower, or "dissecting frogs and learning all the parts," or naming all the bones in the body) that are isolated from the rest of the curriculum. What has traditionally been perceived as science content is now embedded in a conceptual approach to learning "how science works."

For example, rather than simply lecturing about feedback and restoring mechanisms in the system, Eric engaged students in a general discussion of these systems, helping them connect it to their prior knowledge of common systems and how feedback and restoring mechanisms operated in each. Instead of ending there, as a traditional class might, Eric asked students to further explore this concept and elaborate on their understanding of systems by building and testing a solar shoe box.

In the new science curriculum students explored such science topics as: plate tectonics, electricity, meteorology, human physiology, genetics and genetic engineering, animal adaptation, paleontology and evolution along with the laws of motion, but what was different was how they learned this information. There was a greater emphasis on reflection, discussion and hands-on activities. Teachers of the science reform at FSMS looked for their students to "think and interpret and reason" and to be involved in their learning as they discovered "how science works." Amidst organizing themes of patterns, change, diversity, limits, and systems, the reformed curriculum included the following learning outcomes:

- to recognize patterns
- to develop explanations for patterns, and use them to predict
- to distinguish among trends, cycles, and correlations

- to develop an understanding of casual relationships through "if-then" statements
- to learn to create operational definitions and control variables
- to interpret normal curves;
- to develop scientific explanations and understanding the evolution of scientific explanations;
- to understand dynamic balance in systems and recognizing change in systems;
- to differentiate between evidence and inference
- to understand limiting factors

Many teachers, administrators, and students at FSMS referred to this new approach to science education as "process science," which means that science is seen as a "process for learning"--that science does not provide all the correct answers, but requires problem-solving and decision-making to construct understanding. Karen, an eighth grade science teacher, described the four basic steps in this process: " ... You come up with a question, you gather evidence or you read research ... and you come up with information, and then you come up with a possible answer based on that, and then you test it ... " When Eric was asked about the goals that he had for his students as part of this science program he said that he tried "to keep it structured so that we're teaching them ... some of the science things that you traditionally do ... [b]ut also what the process of science is ... what you do to go about it ... " Similarly, a student described "process science" as:

> We look at patterns and see if we can figure out patterns ... we try to explain things that we don't know about ... we ask questions ... and then we gather our evidence ... then we make an explanation ... we usually test our explanations.

This student used a recent class activity to illustrate this approach to science:

> When we were doing the 'If-Then Box,' which is when we were using circuits, we experimented for a while with the circuits, with red and black alligator clips ... then we did an 'If-Then Box' ... It was just a box and it was taped up and ... had thumb tacks in them and it was [labeled] A, B, C, D, E, and F and there were wires inside the box ... which we couldn't see..[W]hen we touched the alligator clips to the thumb tacks on top ... if it lit up then we would say, 'If this lights up, then these two are connected.' So that's how we figured out that those two were connected. So we just kept on asking questions until we were done ... [A]fter that ... we were supposed to test our explanation. We had a bag of stuff and we'd try to make a model of the 'If-Then Box' instead of opening it. It had wires and there were thumb tacks, just like the 'If-Then Box' and we'd try to connect the wires so it would work just like 'If-Then Box.' ... [T]hen we'd have to test it and if it worked then we were right.

The scope and sequence of the program had a "cyclical nature." Key concepts and learning outcomes were presented continuously throughout the year and throughout the following grade-levels of the program as well. Facts were not presented once, tested, and then forgotten, but, in contrast, scientific and technological concepts were repeated, connected, linked, and built upon throughout the middle school science program for the duration of the student's school experience at FSMS. One student described the process as

> ...instead of having each chapter after chapter you drop everything you learned and start over, we just keep on building. And it ... sort of exercises your mind to have to think back all the way to the beginning of the year to think what something is and it keeps your brain like, it keeps on moving instead of dropping and ... stop[ping] dead and then you have to build it back up.

This new, integrated, process approach to science was in contrast to the district's high school science program which took a discipline-segregated, "layer-cake" approach to course-taking. In other district middle and high schools not involved in science reform, the science courses were in a layered, hierarchical order (i.e., biology, chemistry, and physics). Students in these science programs were not likely to have hands-on, laboratory activities and would be expected to memorize isolated facts to be repeated on tests. Their teachers were expected to be bearers of knowledge. This was in stark contrast to the new roles and behaviors Fort Sheridan teachers and students were expected to assume.

Key Features of the New Science Curriculum

Therefore, in order to facilitate students' movement toward the stated learning outcomes, the reformed science program refocused the curriculum structure and instructional methods in several significant ways:

1) emphasis on process science
2) integration of the disciplines
3) focus on conceptual learning
4) use of "hands-on, minds-on" instructional approaches

In addition, the use of cooperative learning, the development of new roles for teachers and students and the use of assessment as a reinforcer of curriculum played a vital role in an effective process-oriented science program. It appeared that teacher knowledge and beliefs in these areas strongly influenced the depth of the reform within the classroom. This section will examine these elements in more detail.

Use of "hands-on, minds-on" instructional strategies. The "hands-on, minds-on" experiential approach was a critical element for the successful implementation of this program and is one feature of the program that is most consistently implemented across the science classrooms at FSMS, though some teachers implement this approach more often and more successfully. Regularly, students used their prior knowledge and had common experiences that were cooperative and collaborative as in the case of mastering tubular waterfalls, designing a solar shoe box system, or testing and creating an "If-Then Box." The emphasis was always on doing, on active rather than passive learning. Karen believed that a "hands-on program" that uses a "process rather than a product sort of viewpoint" really made a lot of sense "because ... the kids learn by doing."

Students also believed that being actively involved in hands-on activity was important in their learning:

> ... [W]e have a lot of hands-on things to do and that's what I like to do 'cause if I just read something I mean I ... probably won't remember what's going on, but when I'm ... actually looking at the thing or touching it or something like that, then I can really focus on what's going on.
>
> I got here [from another school] and it was like, 'Oh, great, I actually get to do this!' ... then you do it and then you understand what's going on ... you do the project and you say, 'Oh now I know what they're talking about.'
>
> We demonstrate it ... that makes it easy ... so I can get an idea of what ... they're talking about and ... when we talk about something, I don't have to visualize so hard ...

"Hands-on, mind-on" activities were critical in that they were engaging for middle school students. Eric believed that it was important to make "science interesting, so [the students] don't get turned off to [science] at this level ... They're actually doing something, they're doing something with their hands" and through their hands-on activities, the students "really get into some of the concepts that they're learning. There are some real high level things ... They're getting a lot of the stuff in the process of doing it rather than lecture-type situations."

Development of new teacher roles. At FSMS, some of the teachers came into this science reform program with a better understanding of key concepts, strategies and skills needed to successfully implement the curriculum than did other teachers. For these teachers, the implementation of this program was seen as a much desired vehicle to help them implement new instructional approaches. Other teachers were resistant to the change because the science reform curriculum was quite a departure from what they normally did in their classrooms. Such teachers felt that they had been teaching successfully for many years and saw little need to make changes in their instructional approaches.

The hardest role for some science teachers to abandon as part of the reform was that of teacher as transmitter of knowledge. Those teachers who most successfully implemented this curriculum reform adopted the roles of facilitators, motivators, and questioners. One teacher said, "I'm a facilitator; I keep people on track." Another shared that,

> This curriculum has taught me to encourage my students to be free thinkers, problem solvers, and teachers of themselves. I have learned to set up a lesson with limited direction and watch as my students develop their own plan for learning. I've become a facilitator and motivator for learning, not just a teacher of information and facts.

When in the role of facilitator, teachers raised questions and initiated activities, assured that students had specific cooperative team roles, provided materials, kept the students going by engaging them in questions, observations, and discussion. Part of the teacher's role as facilitator was to guide student learning through questioning, rather than lecturing.

> I ask questions, I once and awhile point out something that maybe they haven't seen, not an answer but a particular occurrence, event, or something. 'Did you notice that this happened? ... Did you include that in your explanation? ... Is it something you don't think is important? Is it just a fluke? Does it mean anything?'

Teachers asked for explanations and evidence as students processed their investigations and the "hard questions" presented in class, as illustrated in the exchange between the teachers and students in one sixth grade science classroom:

The teacher asked the students to read a section of their text which read:

You have gone to watch a parade. Someone standing nearby says, "Look at those dark clouds in the sky, and listen to that thunder. I'm sure it's going to rain on the parade."

1. Do you agree with the person's conclusion? Explain why or why not.
2. How could you test the conclusion?

The teacher then gave the teams five minutes to discuss the selection. She set her timer.

At one table where I sat, the students read and talked about the questions. One student said, "I don't agree; it could be smoke."

The timer signaled that time was up,

Teacher: "Will it rain?" She asked for a show of hands: 4 said "yes", 10 said "no", and 10 were unsure. "What was the conclusion? Can we have many different answers? There's no right or wrong answer. Dark clouds in the sky and thunder - it will rain. Do you have prior knowledge of that?"

> Several students: "Yes."
>
> Student 1: "Sometimes there are dark clouds and thunder and it may not rain."
>
> Teacher: "Have you experienced that?"
>
> Class: "Yes."
>
> Teacher: "Fence sitters, why are you fence sitting?"
>
> Student 2: "The clouds might be far away and the winds might blow clouds off course."
>
> Student 3: "With dark clouds, it could rain before or after the parade."
>
> Teacher: "Do we have enough evidence to make a conclusion?"

> Student 4: "I can hear thunder from far off."
>
> Teacher: "We can hear guns from off in the field, too. How can you test this?"
>
> Student 5: "Stand out and wait 'til it rains."
>
> Teacher: "Or until it doesn't. I guess you guys are probably right. We probably don't have enough evidence. You need an explanation of your own."

In the new role of facilitator, this teacher did two things. First, she helped students find their own answers based on scientific inquiry and evidence rather than accepting facts or information because it was given to them by the teacher or the textbook. This process is central to constructivist learning where students are expected to construct meaning through questioning and discussion. Next, she engaged in less "teacher talk"--less teacher-dominated talking such as lecturing or teacher directed presentation during the science class period. In some classrooms, a few teachers still defined and explained terms and concepts to their class before students had had an opportunity to read about, explore, sort out, or explain concepts for themselves, but on average students talked more as a whole class, in small groups, or in pairs than in the traditional science classroom as a result of teacher's new role as facilitator.

Expectation of new student roles. In addition to the adaptation of new roles for teachers, students experienced a shift in roles and responsibility as part of the new science program. An important aspect of this reform was that students be more responsible for their own learning. Traditionally, students in science courses are primarily passive learners who look to the teacher as the transmitter of knowledge. Now students were being asked to be active participants in their learning. Rather than listening to lectures, doing worksheets, and reading the textbook chapter by chapter, students were now expected to come to class and share their thinking on particular questions and problems and to explore their answers and solutions through hands-on investigations.

Students engaged in the role of responsible and involved learners had a distinct appearance in the classroom. Karen described her students at work:

> You come up with something based on what you've got and if it's not right, well you just sort of back track a little bit and modify and try another approach ... 'This isn't working guys, we've got to do something different.' 'Well how about if we ... ' 'Well that's not going to work because ... 'They have all these heads together and everybody's on their knees with their rumps up in the air ... and their heads together in the middle of the desk ... they're obviously working on something ...

She described them as

> miniature scientists ... going through the scientific process and realizing how it works ... [they] make their own observations and then ... draw conclusions and make predictions and figure out how to test and so forth and then modify and re-test and all those things ...

The students in the science classrooms at FSMS were "noisy, active [and] involved most of the time." Students were required to think, compare, contrast, and connect ideas and information as part of this program, rather than memorize decontextualized pieces of information and regurgitate them. Students saw their new roles in relationship to the increased expectation that they would be thinkers:

> ... [W]e had to piece [dinosaur bones] together and then we had to draw what we think they would look like with their flesh and skin and stuff and what we think their body shape would be.
>
> [Science lessons] are mostly like investigations ... where you have to take this piece of information and link with something else and tell ... why you think this happened and what do you think really happened.

Within this program, students needed to be both critical and independent thinkers. One teacher explained that

> ... students are allowed to be free thinkers within the limits of the investigation/activity. There is really no wrong answer as long as students are able to justify their answers. Although students are sometimes frustrated because they have to think about the question posed and develop answers on their own rather than find the answer in the text, they are able to grasp the concepts.

The students that seemed to have the most difficulty with this role were the students that were perceived as talented:

> ... [T]he students who are really capable or have been really capable in the past in science where they had worksheets and learned vocabulary words find themselves not nearly as successful now because they are having to think and interpret and reason where they didn't have to do that before ... [T]hey go through a period there where they think, 'This is the pits! You're making me do things that I don't know how to do.'

One such student described her frustration:

> The directions are not in a lot of detail ... 'Test how loud this is.' And you know, it's a little bit more, but they don't give you any instructions other than that ... I like to know what I'm supposed to do 'cause it was pretty difficult ... to try to come up with something ... I just prefer having instructions.

If teachers are placed in the new role of facilitator, then students are placed in the role of "questioner" and this role is key to their learning. A teacher explained:

> [O]ne of the key points is ... for them to understand that learning takes place by questioning ... having someone inform you does not mean that you're learning. You have to figure out how this all fits together and fits in with what you know and how you're going to apply it.
>
> ... [T]hey learn how to learn in here. They learn by ... making an observation and questioning it, and gathering information, and hypothesizing and predicting, and then by testing it, which is basically how all learning takes place ... they learn to ... kind of apply that to more of their

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> learning ... to question things, to attach it to information they already have ... to build on one thing to lead to another.

Some students described themselves as questioners, always asking questions of their teammates and the teacher: "I don't like to be lost. I like to be always in the know ... I can't be sitting there and not knowing."

Yet, at times, students were presented with obstacles in their attempts to assume responsibility for their own learning. Some teachers did not permit or provide adequate space for students to pursue the answers to their own questions. These teachers appeared to perceive student questioning, decision-making, and/or actions as making a mistake. They seemed to stop students in this discovery process. The following classroom event provides a vivid example of this:

During the observation time, students were examining their controlled experiments. They had planted one bean seed "normal" as a control and another as experimental, as they had varied one factor. A student started to poke holes in the box that she and her partner had used to cover one of their plants. The plant was supposed to be in the dark. The teacher caught her and told her, "No, you can't do that." She said it loud enough to catch the attention of the whole class. "You can't change it now otherwise how many factors do you have?" She drew the class into the conversation and asked how many factors would that make? The class said, "Two." The teacher repeated, "Two." The teacher told the student that she would have to cover up the holes with tape and paper which she proceeded to do.

In this situation, the teacher attempted to clarify for the student the meaning of a key concept-controlled experiment. What, though, was this student thinking as she poked holes into the box? "My plant is not growing in the dark. Will giving it more light help it?" or "If I poke holes in the box will I be able to see in and not let in as much light as I do when I remove the box during observation time?" Maybe she already saw a possible second factor impacting her experiment. Maybe she asked, "My plant is not getting enough air. Will giving my plant more air help it?" What was this student thinking? In what way was she altering or extending her investigation? The opportunity for the student to learn from her mistake was interrupted by the teacher's intervention.

In taking on a shared responsibility in their own learning, students must anticipate certain outcomes as a result of following a particular line of thinking or inquiry. In order to learn, they must be allowed to accept the consequences of that line of questioning or thinking. This was the position that most FSMS science teachers took most often in order to encourage students' development of new roles in the classroom.

Use of cooperative learning techniques. Key to constructivist learning for students is the need to communicate as they work through the process of scientific problem solving and inquiry. Students can verbalize their beliefs regarding problems and solutions, which provides them with opportunities to understand their ideas and those of others more clearly and to see inconsistencies in their thinking (Glaserfield, 1992). Social interaction is important to the development of thinking skills in that it provides opportunities for individuals to model and observe thinking strategies -- how one analyzes and approaches a problem and puts together arguments. Working with others in cooperative groups allows for scaffolding of thinking between group members in order to complete complicated tasks, answer questions, and solve problems (Resnick, 1992).

Working together, sharing ideas, constructing new knowledge, talking it out, explaining one's thinking were critical aspects of this program that supported the curriculum's constructivist underpinnings and encouraged the utilization of higher order thinking skills. Eric believed that the "social aspects or the teamwork aspect" of science were equally important issues to address in the classroom, since corporate and research teams do much of today's science. He pointed out that, "It is really a challenge to get [students] to work with other people and to be truly cooperative ... "

The development of leadership and communication skills for middle school students are some of the added benefits of cooperative learning. Yet working cooperatively is a departure from quiet seatwork. Cooperative learning brings a different dynamic to the classroom. With cooperative learning, students and teachers must establish new norms: talking and sharing thinking is not only permitted but necessary; disagreements among students are a natural part of the cooperative learning process and not cause for disciplinary action. One teacher spoke about how the hardest change that she encountered with the reform curriculum was teaching students cooperative learning techniques. She saw that some students were "loners" and that others had "a mind set" that the only way to get a good grade was to do their work by themselves.

Cooperative learning did not operate smoothly in all science classrooms at FSMS. Not all students actively participated with their teams in the program's activities. One teacher repeated one such student's description of cooperative learning as "They do the work and I copy." Students who actively participate in science expressed their frustration as they attempted to accomplish tasks in cooperative teams with students who did not work:

> [The teacher] will put me with somebody that doesn't work, doesn't stay on task ... I end up doing a lot of the work. Other people just get off easy.
>
> ... I had bad partners that when you talked to them, it was like talking to a wall ... they gave me no feedback ...

Yet, most students perceived many advantages to working in cooperative groups:

> You get input from other people to see what their ideas are. And you can take that and put it into your answer and make you answer better ... like if you're stuck, you can get some answers from them and then think up your own answer. You're not always having to work by yourself. So if you're stuck you ask them and they can give you some guidelines ...
>
> You get to talk. Usually in classrooms, you can't talk ... I like to talk to people ... You get to know people ... in the classroom, so you make a lot more friends that way ... some people have said that they're nervous when [the teacher] first puts you in the group with a person that you

> don't really know ... 'cause they don't know what to say or do. That's how I felt when I first came into my first group ... I'm OK now."
>
> ... [I]t's kind of hard work working individually by yourself ... [W]ith our groups ... if you're having trouble you can always ask someone else or you can interact with them ...
>
> Well you have different perspectives of looking at things and sometimes you just kind of see what they have to say and sometimes it's better and sometimes you tell them what your idea is ...
>
> ... [W]e ... share a lot of things instead of keeping them to ourselves and writing them on paper and not letting anybody see what we wrote down.

Therefore, students believed that cooperative learning was positive in that it enabled them to interact with others and to share and build on their ideas. They also saw that often there was a diversity of ideas. Students also talked about disadvantages to cooperative learning. Some of these "disadvantages" were, in reality, reflections of the students' discomfort with their new classroom roles. Working together, sharing ideas, and not always agreeing with each other are new learning situations for many students.

> ... [S]ometimes we'll argue over ... the answer to the question and half the time when we argue [the teacher] compliments us ... [the teacher] thinks that it's good that we're discussing science ... and sometimes people get attitudes ... we always have a problem with disagreements, 'Oh now the answer's not right, It's: I'm right and you're wrong' ... We kind of compromise ... and we work it out ... and sometimes I realize, 'Oh my gosh, I'm wrong, I'm on the wrong page ... I'm totally off track and stuff' and they're right and I'm sitting here arguing over it for nothing and sometimes it's the other way around ... But we mostly just talk it out.
>
> ... [P]eople, like if you say something that they don't like, they'll scream at you and argue, they just start being rude. It's mainly opinions. They just think different things. [I would want it to be] not totally agreeable, but so they can work things out [themselves] ... It's not easy, 'cause if the other person thinks a different way, they're gonna stick with it.

One student talked about how hard it was to share ideas with others. He said, "Well, I'm really my own kind of person, so I don't like sharing my ideas with others and I like using my answer and not anybody else's. So I have to adjust to everybody else in my group." He believed that the most important thing that he has learned in science was " ... to work in a group and not always take your own answer and say, 'That's right,' and 'We have to do this,' or 'We have to do that' [but as a group to form an] ultimate conclusion."

Other students talked about how difficult it was to explain what they were thinking and how the cooperative group setting required that "when you're doing your work, you have to explain to everybody what you think ... And then if they don't understand, you got to repeat it again and you got to explain to them what you see ... "

Teachers acted as facilitators to help students gain the necessary communication skills needed to help them explain their thinking to others and to be part of a team. Some teachers regularly put a "t-chart" on the board and had the students discuss what a particular social skill "looks like" and "sounds like" and then had the students practice with their teammates. (See Appendix 2) To reinforce this, the textbooks emphasized social skills such as "working quickly and quietly," "be sure your group understands," and "praise helpful ideas and actions."

Some teachers expressed difficulty in getting some of their students to work with their teams, stay on task, and refrain from disruptive behavior. Often these teachers found that the only solution was to isolate disruptive students or to think of ways to ability group students. It appeared that some teachers took on the roles of the cooperative team members --communicator, manager, tracker, and team member-- in their classrooms. These are the various roles students are expected to assume when in cooperative groups. As a result of the teacher stepping into these roles, they seemed to get in the way of their students' assuming these roles and taking on more responsibility for their learning.

Eric described a solution.

> With this program, the whole classroom atmosphere is ... 180 degrees from what ... it used to be ... there's a lot more noise level, there's a lot more activity. You have to really be a good manager of the students and teach them how to manage themselves in order for it to be ... real successful ...

Teaching students how to manage themselves and to be responsible for their own learning through cooperative learning were key goals of the science program at FSMS. Most teachers acknowledged that experience and knowledge of effective cooperative learning strategies were critical to successful implementation of the science curriculum and that training in cooperative learning was especially important.

Use of assessment as a tool to reinforce curriculum. The idea that assessment tools can drive instruction or influence the curriculum is usually viewed as an undesireable circumstance. The teachers at FSMS though used assessment to reinforce their science curriculum and classroom instruction. Between teachers and grade levels, the types of assessments used in science classroom varied. Despite the variance, the assessment measures used at Fort Sheridan focused on capturing students' thought processes and approaches to problem solving and inquiry. Classroom assessments included: daily assignments, notebooks, portfolios, quizzes, tests, authentic performance assessment, cooperative team assessment, and self-reflection.

Daily assignments. The collection and grading of daily assignments appeared to be the most consistently used means of assessment in all science classrooms. Such assignments consisted of l) student responses to textbook questions that followed investigations and that connected concepts between investigations, readings, and discussions, 2) data collection tables and charts, graphs, and 3) student reflections about individual and cooperative team efforts. Most teachers graded these assignments using some sort of point basis or letter grade. One teacher gave her students the opportunity to redo assignments if they receive a "C" or lower "because I want to know that they're getting down some of the concepts." Another teacher tried to keep the value of daily assignments to 25 points and if the lesson took several days, it might be worth 50 points. He tried to weigh the assignments by the amount of time that is put into them. Letter grades were usually based on the percentage of points a student had earned (i.e. 20 out of 25 points = 80% = B).

Important to consider here is the teacher's criteria when assessing student work. One teacher gave points for completed work but only "graded" the students' written work with a plus or a minus. Students received a plus if "their ideas are on the right track" and they received a minus if their ideas were "not consistent with the investigation."

> Immediately the students realize they need to focus in a different direction. Although students need to be allowed the freedom of thought, they must realize if their thoughts have merit in the given investigation. The plus and minus system does just that without being too critical ... allowing for thinking and creative ideas [and] focus[ing] on the reasonableness of the procedure used to carry out the investigation, not just 'right answers.'

In addition, another teacher talked about how important it was to be open to various student interpretations when assessing their responses to questions to the extent that

> ... You have to be willing to accept answers that maybe you don't think are what they should have there ... but they make sense. The students can do some thinking on their own and say, 'Hey, I didn't think that.' So I think that's good for them to see that ... and I try to make comments on their papers ... say, 'Hey I never thought of this; it's a super idea' and that gives them a sense of ownership in the whole thing, too.

One of this teacher's students acknowledged ownership around her written responses to daily assignments because they represented her thinking process:

> Really the [the answers to the] wrap-up questions can't be wrong because usually they're ... viewpoint questions, "How do you think this happens?" or "Why do you think this happens?" So ... what he's looking for is thought-out answers.

Some teachers stressed the importance of emphasizing the likelihood of more than one right answer; that there is a multiplicity of answers and solutions to problems and that what is important is that students provide evidence for their positions. One student felt that this is a very positive approach to learning. " ... [I]f you can prove your answer, then it's right, instead of having one answer as right and one answer as wrong."

Portfolios. The sixth grade teachers utilized portfolio assessments every six weeks. One sixth grade teacher described portfolio assessment as an opportunity for students to choose their best works and continue to choose work throughout the year to show growth and personal development

> ... [It] encourages students to be responsible for [the] results of their education ... On-going portfolio assessment helps each student understand their progress, monitor their growth, and develop social skills.

The portfolios usually were worth three or more times the points that the students had accumulated on daily assignments throughout the grading period. As a result, they made up a critical piece of each student's science grade. Students who did not turn in a portfolio most likely got an F for the grading period. Portfolios helped to reinforce the science curriculum because they emphasized process.

Notebooks. Students in most of the classes recorded daily information from investigations, such as plans, procedures, data, charts, graphs, observations, and conclusions in a three-ring binder notebook. Students kept all written assignments there. Several teachers kept a running list on one of the classroom chalkboards of all the assignments and activities that should be included within the notebook's covers. A few teachers periodically collected notebooks and checked them for organization and to see what the students had done. When these teachers utilized notebooks as a form of assessment, the point value was fairly high and could be a determining factor in a student's grade.

Quizzes and tests. Most of the FSMS science teachers stated that they did not give tests; although quizzes appeared now and then.:

> Once in a while we have a quiz ... expecting them to recall something or something in a particular order ... no big deal ... I don't give tests.
>
> ... [W]e don't evaluate with the traditional ... multiple choice, true-false tests. I give quizzes occasionally just so that I have a good idea that they know where we're at, but most of the evaluating is done with activities, with things that they do.

The purpose of quizzes was to see what concepts or knowledge the students had grasped and "where they're at." Quizzes, though, did not appear to weigh much within the total context of a student's grade. Most students did not refer to tests or quizzes when asked how they were graded.

One teacher gave a vocabulary/spelling test weekly as he believed that there were many words in the text that his students did not know. He found that the reading level of the book was much higher than the reading ability of his students, some of whom read at a 3rd grade reading level. In addition, it appeared from classroom observation, that occasionally there were terms that described objects or situations in the students' reading that may have been outside of their daily experience. On vocabulary quizzes, students used the week's list of words in sentences. Sometimes they are asked to draw a picture to illustrate a particular word or phrase.

Cooperative learning assessment. Teachers talked about assessing students' use of cooperative skills in a variety of ways as a way to stress to students the importance of mastering cooperative learning techniques. These assessements included "clipboard cruising," end of class discussions, written student responses to textbook questions, and written student reflections. One teacher described how she informally assessed how her students work with their teams with "clipboard cruising":

> The statement 'what gets measured gets done' holds true for cooperative skills ... I evaluate cooperative learning groups for the skill they are using. Students always know the skill that is being evaluated. I have a chart with their names on a clipboard. If the students are practicing the skill they receive a plus; if not a minus. The students call this 'clipboard cruising.' I believe that it increases student awareness of the importance of working cooperatively.

The reform curriculum provides such outlines for student assessment, but this teacher was the only one that used such an approach.

Many teachers had students assess their use of cooperative skills at the end of class. In addition, most teachers included as part of their student assignments the "wrap up" questions that followed investigations. Included there were questions that asked students to reflect on how they and their team worked cooperatively. For example, the wrap up to one investigation included this question: "How much do you think your team could improve moving into your groups quickly and quietly: a lot, a fair amount, a little, or none?"

A few teachers provided students with the opportunity to reflect on themselves as learners by writing about themselves and "what they have learned from an investigation." One teacher perceived that, over the year, this task became "less frustrating" as students began to see their progress and the quality of work that they were doing.

Authentic/performance assessment. The reform curriculum provided teachers with suggested end-of-the-unit hands-on performance assessment. These were activities that provided opportunities for students to demonstrate their understanding of key concepts presented during the unit and to demonstrate the scientific and technological skills and abilities and cooperative learning skills that they had acquired. One science teacher talked about occasionally utilizing these assessments with his students.

District Assessment. Before and during the field test of the reform curriculum, the district assessed students in science with a norm-referenced, objective science test at each grade level. The district abandoned this assessment in 1993-94 as it did not correspond to the goals and objectives of the new curriculum. The sixth grade science team constructed a new Criterion Reference Test (CRT). The development of the sixth grade CRT was encouraged and facilitated by the district's administration and piloted in 1993 and used again in 1994. Other grade levels had yet to construct CRT's for their science students and there was no time table for the initiation or completion of these assessments.

The district also utilized the standardized California Achievement Tests each year, but the only grade levels that were tested in science are grades 2, 5, and 8. Though this assessment did not measure the content and approaches of the reform curriculum, the district was pleased that students did very well on the science portion of the test. The district felt that good student scores on standardized tests satisfied any parents that might have been concerned about the innovative nature of the program. Eighth graders at FSMS averaged in the 54 percentile in 1993 and in the 63 percentile in 1994. The district, though, "value[d] much more" their students' performance on district CRT's and on the most recently developed state science assessments, as these tests more closely matched the goals and objectives of the new science curriculum.

Because of the high student turnover in the district, teachers at one time felt that district test scores were "hurt" by student mobility. Up until 1987, the district would separate out the scores of those students that had been in the district for four years or less. Ultimately, though, it was found that there was no significant difference if scores were compiled with or without students new to the district.

However, developers of the reform curriculum acknowledged that the high transfer rate "hurt the richness of the progression of skill development, especially cooperative learning." It was difficult to measure improvement or decline in student achievement in science in the classroom and across the district when one considered the average student's short stay in the science program as the rate of student transfer at FSMS during the school year is high (39%).

State assessment. The state piloted a science assessment for grades 5, 8, and 11 that focused on "evaluating students' process skills (e.g., observation, recording, analysis, interpretation, conclusions, and inferences ...)." Multiple choice questions aimed at testing students' understanding of how process science works comprised the first section of the eighth grade test. Students completed that section during one class period. An individual project section made up the second part of the assessment and students were given three to four class periods to complete this portion. For this section, eighth grade students were to choose one problem from the four problems given. The students were to design a solution to the problem and then they were to use simple materials to solve it.

As this was a pilot assessment, no statewide or district scores were yet available, but overall the Lincoln County eighth grade science teachers felt that their students did well on the assessment. Teachers thought that the objective section of the test was hard, but that their students did "average" on that portion of the exam. Teachers believed that the students' experience with the reform curriculum aided their students as they completed the problem solving portion of the test.

Summary

While several of the key features important to facilitating implementation were employed in all of the science classrooms at FSMS, *successful* implementation of the science program was very dependent on the extent to which teachers shared a strong belief in the philosophy undergirding the curriculum and to the extent to which they understood cooperative learning and active learning strategies and felt comfortable using them. The adaptation of this science program required a shift in students' and teachers' roles in the classroom that departed from the roles they assumed in the traditional classroom. Although it is not an instructional strategy, assessment played an important role in supporting the science program at FSMS.

III. CONTEXT OF CHANGE

Pathways and Obstacles to Change

Making the shift from a traditional junior high school science department to an innovative middle school program is fraught with challenges. The question teachers, administrators and others often ask a school like FSMS is: What behaviors, policies, climates can we create or encourage to make the transition easier? Looking back over the last four years, many pathways were constructed to facilitate FSMS' change to a more innovative science program that would help answer that question.

Conversely, obstacles also emerged. After conducting on-site interviews with teachers, administrators, program developers, university site-coordinators and other support personnel at FSMS, it was evident that many factors that encouraged innovation and change at FSMS existed simultaneously with factors that also created barriers to successful implementation of the program. The following section provides an in-depth view of the pathways and barriers of this implementation process and explores seven areas in which there exists both behaviors that facilitated change as well as impeded it.

Teacher understanding and belief in curriculum philosophy. One of the most important factors that influenced the implementation of the new curriculum and instructional strategies in this program was teacher belief in the program philosophy and understanding of the instructional strategies it relies on. As one teacher described it:

> I think that one thing that's super valuable is ... not to just throw this in (and) say, 'Here, this is what you're going to teach.' ... you do need a lot of the training and a lot of the background and the philosophy of it to make it successful 'cause you've got to be in that mind set, 'OK this is what we're trying to go towards.

One university staff member stated:

> Some of the teachers came into the field test with a better understanding of these key concepts, strategies, and skills than did others. Those that bought into it from the beginning already had a lot of the skills needed ... to make the program work ... It matched up with what they were trying to do ... and they saw this program as a help to accomplish what they were trying to do anyway.

Some teachers had already successfully used cooperative learning strategies in their classrooms. Some teachers were working to make changes in their approaches to teaching by working with university personnel to develop and adapt effective strategies from outdoor, hands-on science education and by bringing this curricula to their classrooms. This high comfort level with innovation and discovery facilitated the implementation of the program in their classrooms.

Yet, some teachers either lacked the understanding and knowledge of the key philosophical concepts and instructional strategies that were at the foundation of the program or they disagreed with the program's philosophy:

> There were a couple of teachers ... who weren't convinced that the ... new way was ... better than the old way ... and had some problems adjusting ... this was a total departure from what they wanted to do in their classrooms and so they did not have that same kind of philosophy ... of what ought to be going on in the classroom.

For some, there was "an inertia and resistance to be overcome". Such teachers felt that they had been teaching successfully for many years and saw little need to make changes in their teaching philosophy. Teachers who were more teacher-directed had a harder time since the program called for teachers to take on the role of facilitator rather than transmitter of knowledge. This shift from transmitter to facilitator also dictated a shift in primary instructional strategies: less "teacher talk," more student discussion. While all science classes were structured around the new science curriculum, those teachers who lacked a belief in the philosophy undergirding it or lacked skills in the instructional strategies needed to employ it were less likely to implement the program in depth, causing an uneven application of the curriculum throughout the school building.

For example, one teacher, Andrew, described the difficulty he had with learning the new approaches and understandings associated with this program. He cited cooperative learning as a particular problem area. Teachers, program developers, and university support staff all emphasized that effective cooperative learning strategies were critical to successful implementation of this science program. Though cooperative learning was covered often during in-service sessions, for Andrew, it did not appear to have been effective in helping him adopt new beliefs and instructional approaches. This teacher spoke about how valuable a cooperative learning in-service would be as he had no experience with it and his lack of knowledge of cooperative learning "affects everything I do because I don't feel like I'm effective with this ... " He found that he had some students that just "can't work with others" and he tended to separate them and have them sit in desks away from the tabled teams.

It is important to point out that Andrew's beliefs about student learning appeared to conflict with the beliefs necessary to successfully implement cooperative learning approaches in the classroom. Whereas cooperative learning fosters a belief in effective learning situations with heterogeneous groups of children, Andrew still struggled with a perception of teaching and student learning that required ability grouping. At this point in the reform, Andrew had come to realize that tracking was embedded within his belief system about student learning, that such a belief system conflicted with the philosophy of the reform curriculum, and that the new curriculum was not working successfully for him or his students. As he struggled, he also clearly realized the need for assistance for further change:

> I've been trying for two years to take the class on cooperative [learning] ... I borrowed a book to read, but that doesn't do you any good if you don't have people there ... I need to be involved ... I need to have it functional for me.

He pointed to the fact that his colleague, Eric had already had a cooperative learning class "and it proved very helpful." Eric indicated that, indeed, a cooperative learning class had been helpful.

> [T]he biggest thing that has helped me out is taking a class on cooperative learning ... The very first year we field taught I took that class at the same time. So I really felt that that got me into the correct mind set of ... what does it really mean to be ... a cooperative class ... ?

It is important to note that as the reform curriculum was piloted in 1990, Eric was open to the science reform; he felt that it supported the middle school philosophy. His choice then was to immediately take a class in cooperative learning theory and techniques to aid him in facilitating the changes in his science classroom.

In contrast, Andrew was unsure about the benefits of the program and was hesitant to implement the curriculum in his classroom. It appeared, though, that after four years of field test and implementation, Andrew came to a critical place where he saw the differences between his belief system and instructional strategies and those of the reform, and he perceived that further training in this key aspect of the program would be of great value to his teaching. Therefore, it is critical when implementing reform to consider the length of time teachers may need to reach dissonance with their long-held beliefs and approaches. It is important to ensure that support and staff development (through in-service, coursework, peer coaching, and university support) are available to them at that juncture.

In summary, it is important to look not only where teachers are in the process of reform, but also where these teachers began. For some teachers the reform process was an opportunity to use a program as a vehicle to implement new approaches and strategies that reflected where they were and where they wanted to go. For others, it was an opportunity for professional growth and an opportunity to reflect on long-held ideas and beliefs about learning. A university staff member points out that "Some people invite change ... Some of the more reluctant initially gained a lot from the experience. Change doesn't happen overnight. It takes longer for some people."

Teacher communication and support networks. The State Department of Education includes "teachers as well as students" in their curricular standards for a "transformed science program." The State Department of Education contends that both teachers and students must work in open systems. They need to "work together in groups and teams," "communicate effectively," "persevere in long term investigation," and "apply what they learn to authentic needs within their communities." These practices apply not only to the type of cooperative learning situations provided to students, but suggests that teachers also need similar opportunities and forums to talk to each other in order to make sense of the new curricular materials, new roles, and new classroom dynamics associated with implementing a new science program.

Providing teachers with regular opportunities to meet and discuss these issues was critical to facilitate a smoother transition from the old science program to the new one. Many of the opportunities to meet and discuss concerns arose within the context of field testing the science program. In order to present teachers with the philosophy and skills of the new science curriculum, program developers provided staff development during the summer of 1990 for the FSMS faculty and for teachers from other districts who would also be participating in the field test. University science site coordinators were also included in this first staff development institute. Later in the summer, another four days of staff development was provided for teachers at the state university. The purpose of these staff development institutes was to "give field test teachers first-hand experience with the philosophy, goals, teaching strategies, activities, equipment, and materials of the curriculum ... [and] opportunities to learn more about cooperative learning, the instructional model, and interdisciplinary curriculum development." They offered teachers something else as well: a place to talk and work collaboratively.

Throughout the field testing, the administration provided the teachers with release time to attend in-services that were held every few months. It was a time for teachers to share ideas on how the science program was working in their classrooms, to talk about learning theory, alternative assessment, cooperative learning, and management strategies. Teachers were asked to think about their teaching philosophy and to draw upon their prior knowledge about learning. For example, constructivism was presented as a theory of learning - "How do you know what you know?" Ultimately teachers would discuss how these learning concepts and instructional strategies were applied in the reform curriculum.

In all, it appears that staff development and in-service provided FSMS teachers with the most frequent opportunities to develop communication networks. These networks provided forums for teachers to discuss issues as they each integrated their knowledge and understanding of this new science program. One member of the university support staff emphasized that it is important not to "expect everyone to be in the same place" in the change process, "but moving along ... " For those who were unconvinced and resistant, in-service provided them with an opportunity to acquire some knowledge of the philosophy of the program, to gain some experience with its approaches, and to reflect on long-held beliefs.

What seemed most valuable to teachers during the in-service sessions were the opportunities they had to talk with other teachers about the problems that they were experiencing and to hear about the solutions that other teachers were employing. As students in this science program engaged in problem solving, creating and answering questions in cooperative group settings, likewise teachers "constructed" their own knowledge through conversations with their peers. Eric pointed out that ...

> It was probably more helpful honestly to get together with other schools ... and just talking at lunch and saying, 'Well how did this go for you?' 'What did you do on this?' 'Oh yeah that would work for me.' and ... exchanging ideas in that way I think was more valuable than some of the stuff they had us do ... we tried a few of the projects and ... it helped seeing them the first time, but I think the biggest thing was just talking, being able to talk to other people and saying, 'I had this problem with it.' 'Yeah, I had that too. What did you do to solve it?'

During the in-services, teachers would examine new units and work through some of the activities in the new materials in order to become familiar with them and to address any possible difficulties. There were difficulties with the field test materials and some teachers valued the opportunities to "talk about it" and "have their say" that "it's not all perfect" and say "what [was] wrong here."

Some of this valued communication continued to take place between some science teachers at Fort Sheridan Middle School. Beginning with the first field test year, the sixth grade science teachers at FSMS formed a disciplinary team to plan and to coordinate their classroom activities. It worked "beautifully." They would "plan what they were going to do and help each other. Even within the early field test edition, they didn't have much [of a] problem ... " As a university staff member described it,

> The three would structure time. The fact that there was somebody they could go and talk to ... Teachers that were more isolated ... would call [university support personnel or the program developers but it was] not the same as having a colleague. [It is] very important to have somebody else you can communicate with. The people who got together and shared common concerns were less apprehensive.

The sixth grade team attributed their working together as "invaluable" to their success in implementing the program. Lisa emphasized, "We wouldn't have had nearly the success if we hadn't done that. I really think that we had an easier time with it than anybody else because we planned together." Their meetings were a sharing of problems, solutions, and successes.

> And we had every week - 'Oh my god, they ... the floor was a mess.' 'Why didn't you have ... ' 'Oh, I'm glad to hear you had the same thing.' Or, 'Well that worked.' 'How'd that work?' 'How did you make that work?'

Following the field test, they continued to meet once a week during a common planning time in the afternoon. The issues that they discussed included: 1) the materials that are necessary for activities, how they are organized for best use by the students, and the possible problems that can arise with them, 2) how to structure the class for different activities (i.e. teams, size of teams, whole class activities), 3) the modifications to the student-text needed to aid students, to simplify the task or to make the approach to the task more sensible and/or organized, 4) the students' approaches to learning and the successes and obstacles that students experience, 5) the various instructional strategies individual teachers are using (i.e. modeling), 6) the time frames needed for various activities, 7) the methods of student assessment, 8) the sharing of teacher preparation tasks (i.e. copying, locating, and acquiring materials), 9) the science content, and 10) the role of the teacher and the role of the student.

The 6th grade science team stressed to other teachers that team planning would really make the change to the new program much easier. Karen pointed out that team planning was very helpful to her science team:

> I think that we get an awful lot from each other. I think that (other teachers) might find more support than they expect from each other. 'Gee, this didn't work. What can we do?' You know, 'This is a good idea, but it's not working.' If they would do that, I think it would help.

New to the sixth grade science team, Rhonda felt like the support that she received from her science team was very helpful in making the change to her new teaching assignment. "[It is] easy when you have support." During team meetings, Rhonda asked questions like: "How long will it take me to do this?" "Should I plan one class for this reading?" "What did I forget?" "Do you have a problem with your kids overwatering their plants?" Her teacher's guide was filled with yellow sticky notes to remind her of things that were not in the book. They were things which Karen and Lisa shared with her and which were based on their three-year experience with the program.

Among the FSMS science staff, the sixth grade was the only grade level that team-planned its science. The eighth grade science teachers, though, helped each other and shared equipment. One of the teachers described it as:

> [We] will do a lot of that ... talking ... and saying 'I had this problem with it.' 'Yeah I had that too.' ... 'What did you do to solve it?' ... I try to stay a little bit ahead of where [my colleague] is at because we share a lot of things and [my colleague] can benefit from things that I found that, you know, 'Hey do it this way or otherwise this will happen.'

The 7th grade teachers appeared to have little communication with each other. Across grade levels, Eric and Lisa, eighth and sixth grade teachers, shared informally about what was happening in each other's classrooms and seemed to be comfortable with their knowledge of each other's programs. In general there appeared to be little communication, collaboration, or shared vision between the teachers of the different grade levels. When describing the cross grade level communication, some teachers described the situation as "fragmented." It appears, though, that with the conclusion of the field test, a "closed system" emerged where communication between science teachers at FSMS and between these teachers and outside support personnel was neither supported nor encouraged.

Administrative support. In addition to teacher beliefs and teacher communication, adminstrative support at all levels was critical to the implementation of the new curriculum. The initial support of the administration to make this change was a critical factor in the implementation of the science reform curriculum, as the impetus for the science reform came from the district administration. Despite the high interest for the reform on the part of some of the science teachers, there was so much resistance from others, that without the strong administrative push, it seems highly unlikely that the program would have been implemented at this time. As a result of this top down approach some teachers felt that they were not given any choice as to whether to participate in the field test or not ("we had to do it.") which resulted in some negative feelings towards the reform. The top down strategy thus served as a door opening agent for implementation, but also served as an obstacle to the change process.

Despite this paradox, administrative support for change was evident in several ways. The district's purchase of the published curriculum materials at the end of the field test provides evidence of the administration's support of the reform curriculum, of the teachers' efforts during the field test of the program, and of the teachers' role as "co-developers." As stated earlier, in previous years, another program had been piloted in the district, and the administration failed then to purchase the published materials much to the disappointment and dismay of the faculty.

On site administration at FSMS encouraged and supported change indirectly as well. For the most part, there was no concern by science teachers of administrative expectations for quiet classrooms and for students working individually on paper and pencil tasks. Due to the hands-on nature of the science curriculum, there was an expectation that students in science classrooms would be up and about, involved in activities, sitting and talking with team members, and, in general, noisy:

> [T]here's a lot more noise level, there's a lot more activity ... we're real lucky in that ... our administration ... is behind us on this and they ... see the value of it ... if they walk by your room and the classroom's empty and everybody's outside ... hey, that's OK, that there's things getting done ... I think it's pretty key in having ... the support of people that you're not tuned into the straight rows, students lined up, hear [a] pin drop type of thing.

Yet, there were still administrative barriers created due to expectations incompatible with a science curriculum centered around active learning. Some teachers believed that although administrators knew that the reform curriculum engaged students in hands-on science, some administrators fell short in their understanding of the curriculum's philosophy, instructional strategies, and the forms of assessment that are utilized by teachers. This sometimes became evident in the inaccurate communications that some administrators had with parents.

In addition to administrative supports and barriers at the building level, there was also supports and obstacles demonstrated at the district level. The district encouraged teachers to take on a policy role in which they could share their expertise as change agents. For example, the district was involved in the formation of state assessment policy. As the State Board of Education initiated revisions in state science assessments, the Lincoln County School District sent one FSMS science faculty member to statewide meetings. This teacher was instrumental in the construction of a state test that would support a "process approach" to science in contrast to only the acquisition of content knowledge.

The district administration's vision for the future included the implementation of science reform curricula at both the elementary and the high school levels, thus securing consistency in philosophy throughout the district. During the 1994-95 school year, an elementary science reform curriculum that was consistent with the philosophy and instructional strategies of the middle school program was implemented throughout the district. Thus, the administration's vision was one of breadth. Though the district remained philosophically behind the middle school science reform, opportunities and support for developing program depth diminished and/or did not occur.

What also created barriers for teachers was the removal of the valued opportunities for teacher learning through staff development and in-service. During the field test, the administration provided teachers with release time to attend in-service training and staff development. An electronic bulletin board was set up between the school and the program developers, and the school agreed to furnish the modem and pay for long-distance telephone costs. Once the field test ended, staff development and in-service greatly diminished and support for the bulletin board ended.

Also, what has not occurred within the district that would facilitate communication, interaction, and collaboration between teachers is the redistribution of decision-making power from the administration to the science educators at FSMS. During and following the field test, decisions regarding the science program remained the responsibility of the district director of secondary education.

District and school and structures and policies conflicted with the philosophy of this reform. Within the context of the reformed curriculum, the role of the teacher in the classroom changes from the major source of information and the transmitter of that information to a facilitator or coach who engages and encourages students to explore and form their own explanations. The same kind of role change needs to occur with regards to the administration and the teaching staff.

Administrators need to be facilitator and coaches, where they engage and encourage science faculty to problem solve, inquire, and communicate with each other in cooperative and collaborative teams and with other teachers and experts outside of their school so that they can develop further curricular reform and effective classroom strategies and approaches. Teachers need to be responsible for setting program goals and the development of new assessments. For example, the sixth grade science team was encouraged and assisted with creating a Criterion Reference Tests Assessment.

Strong administrative support was exemplified in several ways: 1) a strong push to implement the reform curriculum and hands-on, activity-based classrooms, 2) release time for teachers for in-service and staff development and the support of an electronic bulletin board during the field test years, 3) purchase of the published curriculum materials, and 4) acknowledgment for the need for congruency between state assessment and district philosophy in science education. As the field test ended, administrative support weakened in that teacher opportunities for learning through staff development and through communication and collaboration greatly decreased. In addition, the district administration did not given teachers support, encouragement, or the decision-making power to take on responsibility for setting program goals, developing further instructional strategies, and developing new assessments. Also, there appeared to be a need for additional administrative knowledge of the reform's philosophy and classroom practice. In general, these science teachers held valuable goals for the future, yet they perceived themselves as being "fragmented" as opposed to having a shared vision. In addition, teachers were handicapped in their efforts to further develop the science program and extend science reform.

University coordinators and program developers. Communication between the teachers and the program developers was set up through an electronic bulletin board. Though the bulletin board is still up and running at the program developers' headquarters (IPD), the school removed the modem at FSMS after the field test. Teachers with questions or concerns needed to contact the program developers indirectly through an 800 number with the publisher or by writing the program developers directly.

The university provided support in the context of in-service education, and university support staff also paid frequent visits to FSMS and visited with teachers in their classrooms during the field test. They met with teachers and asked "how's it going" and gave help. When the field test was completed, this supportive framework was lost due to funding.

Ironically, the opportunity to pilot the new science program and participate in the role of field tester lead FSMS down the road to reform; yet, it was the structure of the field test itself that presented them with some of the most challenging barriers to implementing change. Field testing requires the teacher to teach the curriculum as it is written. During a field test, teachers are not encouraged to modify or adjust the curriculum activities to fit their style of teaching or to provide a more successful lesson based on the teacher's prior knowledge and teaching experience. As a result, most of the teachers felt very constrained during the field testing process. A university staff member explained:

> [M]ost of these teachers were ... what I would call pretty good teachers ... teachers who didn't-even when they had a traditional program-just teach the textbook. OK, they were doing their own thing, supplementing it, cutting out and adding things all on their own ... these are experienced teachers. They taught for how long and they have some knowledge and some background about what they think is important and activities that work for them. So now they're forcing this, field testing this curriculum. And one of the things we tried to emphasize was that 'we want this field test to be a field test of what's written, not necessarily a field test of how good a teacher you are in terms of being able to take what's written and adapt it' ... So in a lot of ways they felt very constrained by this. They wanted to take these ideas and run with them and go wherever they wanted with them.

A 6th grade teacher described field testing as "exhausting" :

> ... [I]t was really frustrating to know that, I think we could do it better if we changed this. But in those first two years not feeling like I [had] the leeway to do any of that because I needed to teach it exactly as it was written so that I could give them real feedback on what they were trying to accomplish ... I was free to make suggestions at any time, but I didn't feel like I could do it first and then suggest.

As teachers were required to set aside their prior knowledge of science teaching, one needs to consider the impact that would have on the construction of new teacher knowledge. It appears that such constraints might not only delay dissonance between long held teaching beliefs and practices and those of the new program, but also encourage the establishment of dual belief systems--"teaching as I know it" and "teaching as the prgram outlines it."

In addition to the constraining nature of the rules of the field test, the quality of the materials provided by the program developers created a difficult task for the FSMS teachers. The program developers provided FSMS with the materials and supplies necessary to do the activities outlined in the field test curricula. Yet, some of the teachers found the field test activities poorly written and were exasperated because they just did not work in the classroom:

> It was a mess! Oh my god, that first year, it was, the book was horrendous. Things didn't work. When you'd get into it, ... it was just a mess ... I was so busy trying to figure out what was going on in the book ... I was really upset with this book. It was terrible.
>
> ... [S]ome of it was very bad. Some of it didn't work. Some of it took forever and the kids couldn't understand it and it was placed at the wrong level.

Some teachers also complained about the poor quality of equipment. "They sent ... cheap things that didn't work. We have pieces of equipment that are supposed to do things that would not."

On the other hand, program developers did allow teachers to take on a new role in the process. They recognized "the need to treat teachers as professionals," and the role of the teacher was "co-developer." One teacher saw her role as "trouble shooting. In some cases [as] nit picking." Teachers (and students) were asked for their input into assessing the curriculum and some of their ideas were reflected in the second field test edition:

> They were encouraged to respond to the material [and] ... the following year ... that translated into real differences ... some of their very ideas were in there and that was wonderful! They were very proud.

Some teachers would retry activities and "give it a new twist," and they were paid for any ideas that were used in future materials. It seemed that in order for these teachers to continue to field test the reform curriculum, it was critical that the program developers and university staff interacted with the science faculty and treated them as professionals.

State Department of Education. The state indirectly provided support for the science reforms now in place at FSMS. Through the development of new science standards, the state cleared a pathway for Fort Sheridan teachers to continue their innovations. State developments did not dictate change for the Lincoln County schools when the change was taking place, but later the state was going about the task of motivating other school districts to make those kinds of changes. One state administrator told a FSMS teacher that her school's science program was "years ahead" of the rest of the state.

Under the leadership of a new State Commissioner of Education and the progressive vision of a state legislature, the State Department of Education began to develop science outcomes for the schools throughout the state just as the faculty of FSMS began to field test the science reform curriculum. The state science outcomes were written after much review of the literature, including Project 2061 and the science standards of other states, and with the knowledge that the National Standards were very much still in the process of being formulated. As one reviews the state's mission statement for science education and its statement of philosophy, one would think that the state's writers had at some point collaborated closely with the writers of the reform curriculum. The mission statement reads:

> The mission of science education in [the state] is to develop all students into life long learners who are reasoned decision makers, contributing to the international community.

The curricular standards indicated that the following characteristics must be present in a transformed science program:

Teachers as well as students must:

- be challenged to become skillful thinkers and problem-solvers
- work together in groups and teams
- be creative
- value curiosity
- persevere in long term investigation
- communicate effectively
- apply what they learn to authentic needs within their own communities
- be flexible and adaptable to changes and discoveries
- make connections between the fundamental concepts of our natural world as well as between science, technology, and society.

And the state described the characteristics of quality science instruction as including:

- teaching consistent with the nature of scientific inquiry
- beginning concept development with questions, events, or phenomena that are interesting and familiar to students
- engaging learners actively
- using team approach and cooperative learning techniques
- de-emphasizing lower level memorization skills and emphasizing the higher level thinking skills
- insisting on quality communication
- concentrating on the collection and use of evidence
- valuing respect, risk-taking, equity (gender and ethnicity), and inquiry in the classroom

Though the state's development of reform standards was congruent with the science reform curriculum implemented at FSMS, it was not the impetus for the reform. They happened simultaneously in conjunction with national movements for change.

Though the state standards and outcomes for science education seem to be in partnership with the goals and features of the science reform curriculum of FSMS, as the state legislature pushed for an early piloting of a state assessment, state leaders hesitated to present an authentic/performance-based assessment to the state's schools. The state science curricular guidelines had been in the hands of educators and school districts but a short time, two years, and state leaders did not feel that instructional change had been implemented throughout the state educational system. As a result, when school district representatives met with state leaders to construct the state test, they were met with directives to write objective questions. One science teacher from FSMS told the story:

After spending the whole morning talking about process science, an individual from a state office charged the participants to work in teams to write objective questions for process science. That was conflicting for one teacher; she couldn't see how she could write objective questions for process science.

She went around to the other groups to find out how they were doing and to express her concern and her difficulty in writing these questions, and she found that some of them were struggling as well. After lunch, she approached the entire group. She said, "I'm having a hard time writing objective questions for process science, is anyone else having this trouble? How are you going about this task?" Many hands were in the air indicating the same difficulty.

The state administrator was upset. "I asked you to go and write these questions; that was your job." He proceeded to tell this teacher that she had to realize that not everyone in the state was where she was - where FSMS and Lincoln County Schools were - and that the tests needed to be fair and to reflect what other school districts were doing in their classrooms in the way of science. She said "What do you mean?" and she held up the state guidelines. "In here doesn't it talk about how teachers and students should be doing process science?" He still persisted, "Well other schools are not where you are." But she persisted as well saying, "Shouldn't they be; didn't they all get a copy of this like I did? If they did, why are they teaching in a way that doesn't meet these guidelines and how are we going to get them to teach in this way if we continue to give objective tests?"

In the spring of 1994, the state piloted the new assessments. Eighth grade students were given one class period to complete an objective portion of the test and then four class periods over a period of two weeks to select a problem from four or five options and, as an individual project, to solve it using simple materials. Fifth graders worked in groups to solve a team problem over a period of four days. Eleventh graders spent a class period with an open-ended assessment.

Today, state administrators talk about how they hope that assessment that is focused on process science will "drive" problem-solving instruction. They talk about how "people assess what they value" and by assessing students for the development of process skills, state educators will begin to teach process science. Though state goals and guidelines supported the reform curriculum of FSMS, it was because of the persistent questioning of one of its science educators that state assessment also supports the innovative instruction of the new curriculum. If objective testing had remained in place, the message "people assess what they value" would have sent a disheartening and discouraging message to the educators at Fort Sheridan who had struggled and worked for curriculum change.

IV. CONCLUSIONS AND IMPLICATIONS

In the fall of 1990, amidst a myriad of other changes associated with the move to a middle school philosophy, Fort Sheridan Middle School implemented a new science curriculum. This curriculum featured integrated science disciplines, the critical aspects of technology, an instructional model that reflects a constructivist approach to learning, cooperative learning strategies, and hands-on investigations. But more changed at Fort Sheridan Middle School than the day to day activities in the science classroom. The change in curriculum created a disequilibrium within the entire system that supports the activities, policies and procedures at the classroom level.

Teachers and students were asked to move outside of their comfort zone and approach science in a new way. Administrators were called upon to rethink what their roles and those of teachers should be. In the process of transforming their science department, teachers were focused on new and important issues such as communication networks and curriculum design.

Critical to this reform effort was national funding that enabled program developers to write the innovative curriculum. This funding provided the district and teachers with staff development and with on-site support from the university science site-coordinators and staff. It also provided students with science materials and equipment. Without this initial national funding, this particular reform effort would not have taken place in this district. Yet, the teachers at Fort Sheridan Middle School came to realize that the smooth implementation of the new curriculum depended on more than adequate funding. Whether or not the science curriculum was viable in the classroom depended on the relationships between the various players throughout the system.

What can be learned from this case study is that there is an affective element to curricular reform. In addition to the need for high quality curricula based on current educational research, high quality equipment and high quality teacher training, there is also a need to build and nurture relationships and attitudes.

Conclusions

The factors that were important to successful change at Fort Sheridan Middle school included teacher learning of new instructional approaches and roles within the classroom, long-term support systems, and interactive forums and school structures that would facilitate teacher communication, collobaration, and learning and the development of a unified vision of reform. Several factors served to facilitate the implementation of this reform curriculum. There are five key factors that one can learn from the reform implementation at Fort Sheridan Middle School.

Teacher belief in and understanding of the philosophy and instructional strategies of the program is critical to facilitating change in the classroom. It was important that teachers had a belief in and a good understanding of the reform's philosophy, the curriculum's instructional model, and the program's teaching strategies. At FSMS, some of the teachers came into the field test with a better understanding of key concepts, strategies, and skills than others. For some, the science reform curriculum was quite a departure from what they normally did in their classrooms. Some educators were resistant to the change. These teachers felt that they had been teaching successfully for many years and saw little need to make changes in their teaching philosophy.

Consequently, for some teachers the implementation of this program was seen as a much desired vehicle to help them implement new instructional approaches. For others, the program implementation and its concurrent staff development and in-service served as an opportunity for professional growth; knowledge could be gleaned about the program; and long-held beliefs were recognized and possibly challenged. For all teachers, the implementation of the reform curriculum moved them to a place of change where they might not have moved otherwise.

Communication and collaboration between teachers, students, administrators, university support personnel, and program developers appeared to be a key component to teacher learning and to facilitating the implementation of this reform curriculum. What seemed to be of most value to the teachers in this study were the opportunities they had in the contexts of staff development institutes and in-service education to talk with other teachers about the problems they were experiencing and to hear and to talk about the solutions that other teachers were utilizing. For both students and teachers in this science program, the social construction of knowledge through cooperative and collaborative interactions appears to be critical to overall learning. The state Board of Education indicated that for both teachers and students "communicating effectively" and "working together in groups and teams" were key characteristics of a "transformed science program" the goal of which was to develop teachers and students into "lifelong learners."

Some of this valued communication continued to take place between some science teachers at FSMS. The sixth grade science teachers team planned and coordinated their classroom activities. The teachers viewed their working together as "invaluable" to their success at implementing the program. The eighth grade teachers helped each other and shared equipment. Within their interdisciplinary grade level teams, two science teachers found support from their colleagues for implementing cooperative learning strategies across the disciplines.

However, there was little communication between the seventh grade teachers, across grade levels, or with teachers or others outside of the school in regards to the science program. As the field test ended, the contexts of staff development and in-service education which provided regular teacher communication and interaction during the field test were no longer in place.

There was little encouragement or support for contexts that would provide opportunities for teachers to communicate between themselves or with others about the science program. University science site-coordinators and staff and the reform program developers provided critical support through staff development and on-site classroom visits throughout the field test. As the field test ended, their direct involvement and support for the faculty at FSMS also ended. As district support for forums where teachers could interact with their colleagues and experts in their field diminished, teacher isolation increased. Teachers had no shared goals for further program development and reform. The need for teacher communication and collaboration seemed important for continued teacher learning and for developing a shared vision for program development. Though the administration's support had been critical to this reform, more communication opportunities and new decision-making structures, such as science teams, needed to be created, encouraged, and supported so that teachers could further develop instructional strategies, assessments, and future goals of the reform.

Field testing must facilitate constructivist thinking for teachers. In addition, a key component of constructivist learning is the importance of reflecting on prior knowledge and experience as new knowledge is brought to the learner. Important to consider when reflecting on teacher learning is the frustration felt by the teachers as they implemented field test materials as they were written. Teachers who field test are not supposed to draw from their prior teaching experience and modify curriculum activities. Within the framework of the field test, teachers were asked to set this knowledge aside and teach the pilot materials as they were written. Following constructivist learning theory, their personal learning was hampered by these field test "rules."

On the other hand, it is important that program developers viewed the FSMS science teachers as "co-developers" of the program. The teachers' feedback to the developers after teaching the activities in their classrooms was encouraged and some of their suggestions appeared in later field test materials. This is especially important as teachers often found the field test materials to be poor and the equipment to be ineffective or lacking, making the field test process even more demanding. Teachers played an important part in the development of the program, and it appears to be important that they were regarded as professionals by the program developers in the implementation process.

District administrators and building administrators need to better understand the reform and what that means for teacher and student interaction, classroom instruction, and assessment. Although the school administration supports the hands-on, activity-centered approach to teaching science, some administrators do not fully understand the curriculum concepts, instructional strategies, and forms of assessment used by teachers in their classrooms. This at times results in difficulties with communication between teachers, administrators, and parents and in teachers' not being as strongly supported in their day-to-day classroom activities and interactions as they need to be.

Importantly, the district's administration did not create structures that fostered valued teacher communication and that shifted decision-making responsibilities for program development from the administration to the science faculty. Without such structures, these middle school science teachers were without a means to develop a unified direction for further change and growth; further teacher learning and program development were impeded; and full implementation of the reform became uncertain.

Although it does not immediately affect the day to day classroom interactions, support from the State Department of Education is critical in implementing reform. Throughout the implementation process, the State Department of Education was moving down the same pathway to reform, establishing outcomes and guidelines that paralleled the goals and features of the reform curriculum implemented by FSMS. Further, both the state's belief that "people assess what they value" and their ultimate commitment to the new assessments sent a strong message to the science educators at FSMS that their efforts towards science reform are supported not only by state goals and guidelines, but also by state assessment.

As one Fort Sheridan teacher said, "change is hard." Yet it can be exciting.

What is exciting, is the student involvement and the depth of student learning that it fosters. What is difficult and complex about reform is coming to recoginize and understand the many factors that are critical to its success and also to have knowledge of the obstacles that can inhibit its progress. With such knowledge and understanding, we can foster action that will support change and, importantly, address the limiting factors. In conclusion, change is indeed, a long and intricate process and it needs continued nurturance, sustenance, and support in order to perserve.

V. APPENDIX A

"Change is Hard"

What Facilitated the Change	What Impeded the Change
1. Teacher understanding and belief in program philosophy and instructional strategies	1. Lack of teacher understanding and belief in program philosophy and instructional strategies
2. Teacher communication A. Communication between teachers at in-service B. The 6th grade team C. Communication between grade level science teachers D. Support of inter-disciplinary team	2. Diminished opportunities for teacher communication with others
3. The role of program developers A. Provided staff development B. Provided support through local university C. Provided materials D. Provided support through electronic bulletin board E. Paid teachers for staff development. F. Treated teachers professionally as "co developers" G. Supports toll-free "help line"	3. The role of program developers A. The field test 1. Field test curriculum and materials 2. Rules of a field test a. Teach it as it is written b. Modifications not to be made B. Discontinued in-service support after the purchase of published curriculum

4. The role of school administration A. Implemented top-down reform B. Provided release time for in-service institutes C. Provided staff development classes D. Electronic bulletin board E. Purchased published materials F. Classrooms where students are actively involved	4. The role of school administration A. Top-down implementation B. Did not create new structures for teacher communication and decision-making C. Discontinued support of the bulletin board D. Diminished support of in-service after curriculum adoption E. More knowledge needed of the reform principles and teacher practice
5. The role of the university A. Site coordinator for field test of new science program 1. Provided on-site support and in-service for teachers during the field test B. Presently provides some staff development C. Presently provides some in-service at the request of the school district	5. The role of the university A. No longer provides "free" in-service or classroom visits to support teachers
6. The role of the state A. Science outcomes and assessment support features and goals of the science program B. Trains teachers for implementation and grading of new state assessments	6. The role of the state A. Does not provide for personnel or economic support for general teacher in-service/staff development
7. The role of the federal government A. Provided funding to create the reform curriculum and to finance the field test in schools	7. The role of the federal government A. No longer provides financial support for this reform

APPENDIX B

Show Respect for Others and Their Ideas

Looks Like	Sounds Like
1. Nodding your head	1. Letting people tell you their ideas
2. Smiling	2. 12 inch voices
3. Looking at their face	3. Using your partner's name
4. Checking out their body language	4. "I like that."
5. Get involved with your partner	5. Questioning people
6. Hand gestures	
7. Pat them on the back	
8. Eye contact	

T-Chart

CASE STUDY OF FAIRVIEW MIDDLE SCHOOL SCIENCE DEPARTMENT

JOAN M. WHITWORTH
CURRICULUM REFORM PROJECT
UNIVERSITY OF COLORADO

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This paper was prepared for the Curriculum Reform Project, a study of curriculum change in mathematics, science and critical thinking which is funded by a grant from the U.S. Department of Education's Office of Educational Research and Improvement (OERI Grant #R91182001). The opinions expressed herein are those of the author and the participants in this study.

FOREWORD

When faced with a challenge, a detailed story of someone else's experience in a similar situation generally is of strong interest. In reading someone else's story--be it political history, a chronicle of dealing with a family tragedy, or the story of a major business success--we do not expect to find a formula to apply directly to our own situation; instead we hope to find insight and inspiration. Thus, the story contained in this report should be engaging to individuals committed to educational reform in a local school context. It is the story of one school--or department within a school--engaged in fundamental reform of education for its students.

Similarly, one should not expect to find in this case a model for a specific educational reform to initiate in another locality. Every context is different. Each local school and community culture has its distinctions, each individual's and group's educational goals have different shadings, each setting has its own history, and each school has unique constraints to making change.

Not only does one formula not fit all schools, there is no specific formula for a given school. A central message of our case studies is that educational reform is a long-term process for which there is no detailed road map. It is an uneven process with highs and lows, failures and successes, but gradual movement toward greater and more profound learning for students.

What we can expect to find in this story are insights about new teacher roles, how students go about learning with greater depth of understanding, the context in which such shifts can occur, the challenges that must be overcome to initiate these changes, and actions taken by various parties to keep the process of change moving forward. Reflecting on someone else's story can be helpful in the process of developing one's own plans, collaborating with others to move the process forward, and helping students take responsibility for learning.

The Research Project. The case study reported here is one of nine--three each in science, mathematics and higher order thinking across the disciplines--conducted as part of the Curriculum Reform Project. The cases were studies of individual schools--actually a department within a school in the case of science and mathematics--in the process of solidifying reform. Each was selected because it was a successful example of reform. A researcher spent 20 or more days at the site to learn what changes they were making, the barriers encountered, how they overcame these challenges, the nature of their successes and their hopes for the future.

Site Selection Criteria. Sites were sought which had initiated reforms consistent with those recommended by leading groups in the respective field, e.g., the Curriculum and Evaluation Standards for School Mathematics (Commission on Teaching Standards for School Mathematics). Final selections were based on program outcomes including student test scores, enrollments in subsequent elective courses in the given subject area, and professional judgments about the quality of the curriculum provided to students.

Site Selection Process. The search process began with the solicitation of nominations from researchers and knowledgeable practitioners across the U.S. Key people at the nominated schools were contacted by phone to get additional information and written exchange of information followed. Selection according to the above criteria resulted in schools spread across the country with considerable variation in location (e.g., urban vs. rural), economic level and ethnic makeup of the communities.

Research Methodology. In each case the researcher was immersed in the activities of the school and collected a wide range of information. Data included classroom observations, interviews with students, teachers and administrators, and a variety of documents from the site. The voluminous field notes and interview transcripts were analyzed and an interpretative report written.

Cross-site Analysis. A cross-site analysis of the nine cases was conducted to gain perspectives that extend across the sites. An individual case is rich in description and context but does not contain the depth of analysis that can come from looking across a number of cases. Thus, the reader is referred to the Project's cross-site analysis. Main points from this analysis to bear in mind while reading this one case, however, include the following:

- The reforms being sought are profound and demand major changes in teacher and student roles.
- The process for achieving such reforms is complex and demands a long period of time to attain.
- The schools in these cases have traveled a considerable distance on the road to reform but have not yet "arrived."

These cases are presented largely--though not exclusively--from the perspective of the teachers at the center of the cases. This perspective reflects the nature of the reforms and the way they have been initiated in each school. This perspective may be particularly important for initiating change. Our cross-site analysis shows that changes in teachers' values and beliefs--not just greater teaching skills and techniques--are central to reform. While changes in student roles and student work are the ultimate "bottom line," these teacher changes are an important intervening step.

We hope your reading of this case stimulates both interest and significant reflection about reform activities in your school.

Ronald D. Anderson
Director, Curriculum Reform Project
University of Colorado

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I. INTRODUCTION

With the rapid advance of technology and science shaping the way in which we live, many educators, policy makers and social scientist warn us that our children may not be prepared to deal with the advanced technologies and scientific environments that await them in the next century. In response, many states, school districts and professional organizations of scientist and science teachers have taken up the challenge to change science education at all grade levels.

This case study describes the implementation of a middle school science reform curriculum. It is hoped that through such studies, science educators, policy makers and program developers will have a better understanding of what is needed in order to successfully implement curricular reform in science education. The purpose of this study is to describe the substance of the reform at this particular site along with an analysis of the factors that have been critical to its implementation and the dilemmas that have emerged as a result of the implementation process.

Data Collection

Data for this study was acquired through on-site visits and classroom observations over several months. Data was primarily collected through classroom observation, faculty meetings, interviews with teachers, as well as interviews with school administrators and program developers.

The Site

Fairview Middle School (grades 6-8) is located in the little town of Cedarville, where a large, rapidly growing city of approximately 50,000 people encroaches on its boundaries. The student population of 800 students is evenly distributed among grades 6, 7, and 8. The school draws from a low income area of the city, a middle income suburban area, and the original rural community of the area; it reflects the 50% minority composition of the district, due to federally mandated integration.

The school operates under the strong leadership of a principal who came up through the ranks and has a reputation for "getting things done." This past year he lobbied three area businesses to contribute over $90,000 for a computer lab. A close working relationship exists between the staff and the principal. They believe that he is responsible for what they perceive to be a good teaching situation and feel that he is very supportive. One science teacher related the story of how the principal works with the teachers and supports their efforts. The principal sent the custodian and his truck to the local lumber supply and then enlisted the aid of the shop teacher and his students to build ramps for a unit on motion:

> . . .our principal has been very supportive, so our administration has been supportive of our efforts. They have been encouraging of what we do, flexible in terms of what we do, flexible in terms of having folks like you come in and visit with us, and do things with us. As well as us leaving to go and meet statewide. I mean, if you didn't have your administration understanding

> that it may require a little more of your teachers than perhaps what the administration has in mind for you, I don't think it would work.

In the school there is an atmosphere of cooperation and collaboration among teachers who are on the same team, and even between teachers of the same grade level. This cooperation is facilitated by team planning time being built into the school schedule and a common lunch period for all teachers of a particular grade. But this collaboration does not carry over to teachers of different grades, nor to teachers of the same subject area, unless their classrooms are in close proximity.

In addition to the leadership of the principal, Fairview Middle School teachers participate in shared decision-making through the Planning Leadership Team (PLT), which includes all the team leaders. Each grade has a minimum of two teams. The lunchroom manager, head custodian, and a teacher's aid are added if a decision involves the whole school. In the future, parents are to be included.

Background Context

After Fairview adopted the middle school philosophy and made the transition from a junior high school to middle school, the principal and a core of teachers saw a need for curricular change. They decided one area ready for change was the science curriculum. They examined several other reformed science curricula projects before becoming involved with the State Project for Reform in Science Education (SPRSE). The state reform project was organized under the framework of the National Science Teachers Association's Scope, Sequence and Coordination project.

The SS&C developers' original purpose was to form a synthesis of the best research and development efforts in education. They focused on developing a curricular model that emphasized greater depth of understanding for the student and less coverage of science content, while maintaining the appropriate sequencing and consideration for child developmental levels. At the center of the SS&C project are six core principles:

- Spaced presentations yield substantially better learning than do mass presentations.
- Learning is not improved by ability grouping.
- Students learn from each other in cooperative learning situations.
- All students should learn science.
- Students should learn through practice, problem-solving and carrying out experiments.

- New information should be connected to prior student knowledge.

Out of these principles, several major processes and procedures take shape within this reformed science curriculum:

- Teaching science a few hours a week over several years instead of concentrated into one year is a strategy designed to extend the coverage of science concepts over a longer time period and to give experiences in different contexts.
- Key science concepts appropriately sequenced and coordinated among the science disciplines enable students to encounter concepts, principles, and laws of science at progressively higher levels of abstraction over several years.
- By building complex scientific relationships over time, qualitative relationships are established, measurements are understood, and empirical relationships are found. As a result, students construct theories from which new predictions are made.
- Hands-on experiences, preceding the definition of terms and the naming of concepts, are used to generate student interest, thereby motivating students and challenging their preconceptions.
- Student assessment is performance-based.

In addition to using SS&C principles and processes, the SPRSE curriculum developers used materials from the American Association for the Advancement of Science's (AAAS) Project 2061, National Assessment of Educational Progress (NAEP) Goals, National Research Council's Science Standards, and The American Geological Institute's Earth Science Framework to draft a state framework. Teachers from around the state later added their ideas to this framework to construct the state's version of the new science curriculum.

The two universities, Western State University and Eastern State University, which managed the implementation process selected seven pilot schools in six counties across the state to serve as pilot schools for SPRSE. The principal and science teachers made the decision to become a pilot school for SPRSE after meeting with a representative from Western State University. In the spring of 1991, teachers and university personnel working with the state science reform project began field testing curriculum materials in the sixth grade classrooms. The seventh grade teachers implemented the new curriculum in the 1992 school year, followed by the eighth grade science teachers in 1993.

Financial Support. In addition to funds received through a grant from The Nation Science Foundation (NSF)--designated for teacher training and technology development within the six pilot schools--the district allocated $10,000 for computers, and $2,000 for software to be used with the science reform program. The principal at Fairview stated that the great majority of the cost of implementing the program came from the local university, including $1,000 to buy science materials. The school's expenditures were for release time, substitute teachers, and lodging for participants to attend meetings and training sessions.

II. THE REFORM CURRICULUM IN PRACTICE

A Classroom Visit

> Sara Miller, one of the 6th grade science teachers, is addressing her class at the end of the hall. On the walls are student produced drawings of the sun and the planets taped at varying distances from each other. Sara tells the class that she is taking them on a tour of the solar system. She walks over to the sun and stretches her arms to encompass the first four planets and has the students comment on the relative closeness of these planets to the sun and each other. Then Sara and the class walk the increasing distances from planet to planet. When the group has reached the end of the hall and the final planet, Sara has the group turn and look back down the hall toward the sun. Several students make comments about how far apart the planets are at the far reaches of the solar system compared to the relative closeness of the planets close to the sun.

The new science curriculum at Fairview stressed two main points: students should have a greater depth of understanding of science concepts, and they should be making connections among the science disciplines and with life experiences outside the classroom. In order to achieve these goals, the principles undergirding the new science curriculum suggests that the roles and responsibilities of students and teachers must shift. As highlighted in the above vignette, students are up and out of the classroom, learning science in a new way. Yet, most of the teachers at Fairview Middle School did not feel that teaching under the new curriculum was much different from what they were doing prior to implementing of the reformed curriculum.

Teacher Perceptions of the New Curriculum

The science teachers at Fairview felt little had changed since implementation of the new curriculum. They believed they had already been doing a fair amount of cooperative learning and hands-on activities. In their opinion, the differences between teaching the SPRSE curriculum and teaching the other curriculum in prior years were minor. The changes they did cite as a result of the new curriculum were:

- Increased verbalization with the students
- More student interaction
- Increased teacher demands
- Coverage of less science content

They compared the way they taught science in the past to how they are teaching science now:

> Well, there's minor differences, and there's major differences too, Some of the curriculum is the very same concept that we were covering in the ... using the textbook. The biggest change is more, I think, verbalization with the student, and less of them doing an assignment out of a book and answering questions that are textbook-oriented. These questions are more teacher-oriented

> and student-oriented, and originating questions, and not having a book. Your book is now a reference that we use sporadically. It's just a different approach to teaching...
>
> But you know, I think most science teachers, or all science teachers at our school, have always been very much activity-oriented. So what we're doing is different, but it's not that different from what we did before.
>
> ... They sat at tables because of it being a lot more practical as far as science experiments, the flat top surface, and that kind of thing. So, no, we were already grouped and doing the cooperative learning. But it's even, with this, more cooperative because you are ... you as a group are working together on answering questions, or doing experiments, sharing your data... Not everybody with their book, their own book. Their own set of things. There's almost constantly a group interaction.

Another teacher described the reform program in her classroom:

> And so it's social interaction ... and those aspects of human relations that comes into it. So you've got a lot of different threads being woven into your curriculum. It's not just science information and facts, and hands-on activities. It's human relations, and time management, materials management. That's been really, you know, really demanding.

Teachers suggested that teaching science didn't look different because they had been using innovative teaching strategies prior to the curriculum change, but as the following vignette hints, science education at Fairview did not look very "different" from science education in previous years because what had not occurred was a significant shift in the role of the teacher in the classroom. As illustrated by the teacher in the vignette, some teachers had not relinquished the role of transmitter of knowledge and director:

> Students come into the classroom and take their seats. The teacher instructs them to get into their cooperative learning groups. The students shuffles themselves around the room until they are all sitting with their appropriate group. On each table is a pitcher of water, a clear shoe box, a plastic model of a volcano, a sheet of plastic, a graduated cylinder, and a black grease pencil.
>
> Today the students are going to use these materials to construct their own contour maps of the volcano in their group of four students. The teacher directs the class to place their volcano models in the plastic shoe box. After cautioning them to be careful and not spill the water, she tells them to pour 10 ml. of water into the plastic shoe box. When they finished this maneuver she instructs them to put everything down while she comes around the room and looks at each group's set-up.
>
> She then tells the students to make a black grease pencil mark at the water line on their volcanoes. The teacher goes on to tell them to pour 10 more ml. of water into their shoe boxes and again draw a line at the water level. After each addition of water, and each line drawn she checks each group's set-up. The class ends before the activity is finished.

In theory, cooperative learning in the classroom provides an opportunity for the teacher to step out of the role of director and become a coach, encouraging students to take responsibility for their own learning. While Fairview teachers attempted to employ new teaching strategies such as cooperative learning more, their actions demonstrated a lack of confidence with these new methods and discomfort with their new roles. They were often observed directing students in a group activity or asking students to brainstorm or explain concepts in their own words, but they ended the class with requiring students to copy notes or vocabulary--in textbook or teacher terms. In addition, teachers still spent much of their time directing student actions, asking questions, and providing information to students.

Several teachers identified the dialogue which enables students to come to an understanding of the science concepts as the most important ingredient in the program. Yet, this dialogue followed the pattern of teacher question-student answer-teacher question or comment. One teacher did explain how he was striving for student-student dialogue, which he was able to attain periodically:

> That's when you know you've been really successful and the kids are really involved but it's very difficult to achieve.

One of the teachers who had been with the project for two years stated that as she has gained experience with the program, she has become more comfortable with it. She felt the students did benefit from this new approach to learning, although she covered less material than she did with her previous teaching strategies:

> Well, since I've had a year of doing this, now I'm very comfortable with doing the reform program. I think because I had the summer to help make changes in the curriculum that I felt needed to be made. And because I think that a lot of students should really learn more by discussing it the way it's presented in this way. I think, you know, the down side of this is that we do spend a lot of time just ... a lot of time discussing and going over things. We probably don't cover as much material as I did in the past.

This sentiment is echoed by another first year teacher who stated his feeling about the science reform program:

> I love the activities, I really do. And I am enjoying the program. But I just felt like, as a teacher, I wasn't meeting some of the needs they need. I felt like they needed some vocabulary.

Science Content. While the SPRSE curriculum stresses covering fewer topics while going into greater depth with the material that is covered, many teachers at Fairview expressed some uneasiness with this approach. In the classroom, they did follow the structure of the new curriculum, which organized the science content around major themes and presented the sciences as integrated units instead of isolated disciplines. But most teachers still believed that students needed to know the facts and vocabulary of science. They often ended classes with the students copying facts and vocabulary from the board or from an overhead transparency. Students dutifully copied these notes because they knew they would be required to recall these facts on traditional student assessments such as quizzes and tests.

This issue of coverage and the science content was exacerbated by the fact that with the new curriculum there was no textbook. Teachers copied materials from their own SPRSE notebooks. Many of the teachers used other supplemental sources outside of the SPRSE curriculum materials. Students created their own textbooks by keeping journals consisting of class notes, activities, and laboratory exercises. Several students expressed the sentiment that they liked making their own textbooks. None of the students interviewed said that they missed using a text or wanted to go back to a textbook.

Yet, some of the teachers, especially those new to teaching, felt differently. Some said that they would like having a textbook as a companion to the project. Their main reasons were that they would have something that the students could take home and that they would have something to fall back on if the class became disruptive. Other teachers expressed their belief that not all students learn in the same manner, and felt some students could be helped if they could read about science concepts. Some teachers did not want a textbook but felt that a set of science resource books would be helpful.

The plan to give teachers "ownership of SPRSE" by having them write their own curriculum, in place of using a commercial textbook, created another problem for the effective implementation of this new science program. Many teachers felt overburdened by this role and felt they could not teach and write curriculum at the same time. Once the teachers had "used up" the SPRSE units developed during the summer institute, they proceeded in their individual directions. Some teachers did not agree with the philosophy and/or principles of the project and returned to their original teaching strategies. Others felt burdened by personal and/or professional demands and did not feel that they had the time to continue curriculum development.

Student Roles and Rewards

Despite the resistance to change demonstrated by some Fairview teachers, students, in general, had taken an active role in their own learning and appeared to be involved in their science lessons. They were often observed developing hypotheses, collecting data, and journaling. In addition, students engaged in many group activities such as brainstorming topics to facilitate critical thinking, making decisions on how to present information to the class, and evaluating the work of other class members.

All of the teachers--even those who have reservations about the reform program--agreed that one of the primary benefits of the new curriculum was that the students were more interested in science and appeared to enjoy their science classes more. One of the teachers new to the program recounted an incident that illustrates this point. His class was going to miss science because he had to be outside working on another project. He took them "out to the field" but the students begged to go inside and "do science."

Other teachers assessed their students' reactions to the science reform project:

> Well, I think in general the students certainly like the activity, you know, the fact that we're activity-based. They think the classes go quickly because there's a lot to do. There's a ... I mean, in any one class you may come in you may do something in your notebook, you may summarize some data, you may work on a graph or a chart, you may go outside, or you may get up at your table. I mean, there's lots to do. I mean, the students will quite often say, "Boy this

> class goes by fast!" because they are very involved in one class period. I think, certainly they like the activities because by being in cooperative groups they have a chance to talk.
>
> ...Like a little note dropped on my desk saying, "Dear Ms. Miller, Last year I hated science, but I sure do like it this year." Or on a Christmas card that says, "I think one day I might be a scientist."
>
> There's no question about it. Kids love it. They would rather be active and working with a group than staring at a book.

Informal interviews with the students between classes, in the hallways, and while they were engaged in science activities supported the teachers' views. The only students who expressed any dissatisfaction with the program were transfer students from other schools who had previously been engaged in traditional science education at the middle school level and now suddenly had to shift to a new orientation.

Another benefit to students cited by the teachers was increased student self-esteem. Many who felt they could not do science, now felt they could. This fact was evidenced by the increased number of students applying for the advanced eighth grade science class. An eighth grade teacher expressed concern that maybe it does "too good a job," giving students a false impression that they can do something that they really can't:

> The grades are higher which is good because it helps build self-esteem. But it can also give kids a false sense of what they can do. We've also had to move more kids back from accelerated this year. If they weren't getting a 77 by the end of the first grading period they have to go back into the regular science class. This year we had to do more of this. I think we need some realism.

But, overall, they felt that because students are more interested in science, and more successful in science the number of failures has decreased. One teacher stated that she only has one or two failures a year now. Others stated that their failures were less than six or "just a few."

Although several teachers agreed that they covered less content in the science reform program, they also stressed the fact that the students remembered more and understood more of the material they did cover. One teacher new to the SPRSE classroom contrasted the amount of material remembered and understood by her textbook-oriented science class of last year and this year's reform science class. In her opinion the reform class was able to discuss concepts covered many months earlier while her previous class forgot material shortly after they were tested.

Teachers also felt that their students in the new program were able to score as well or better than the students in the old program on standardized tests:

> They are anywhere from on the same level to above the level they were before. But let me qualify that, with saying they are taking the very same state 6th grade science test that all my students have taken.

> But we're taking the old test, but we're not following the old curriculum. And they are still maintaining or doing better than what my students have been doing in the past.

The results of the Southeastern Regional Vision for Education (SERVE) annual evaluation of the SPRSE project have not yet corroborated Fairview teachers' observations but do suggest that students are heading in the right direction. SERVE compared student achievement in the pilot and control schools as measured by the State Sixth Grade Science Test. The state test is a sixty item, multiple-choice test which measures achievement in science from 4th, 5th, and 6th grades.

It is comprised on 5 subscales, each consisting of 12 items. The subscales are life science, physical science, earth science, nature of science and science process skills. For each project school, one comparison school was selected from the same district. Prior to the implementation of the science reform project the two matching schools were comparable on the 1991 Science Test raw score means. The conclusion of the SERVE evaluation on student achievement is as follows:

> In order to make the sixth grade science test score more instructionally valid, the test items were adjusted using teacher ratings of content coverage. In order to make the scores comparable, control school scores were also adjusted. This adjustment resulted in an increase in mean score for project and control schools. The increase for project schools was almost eight tenths of a point higher. Additionally, the mean difference favoring control schools decreased from .93 points to .09 points with the adjustment of test scores to reflect content taught by both groups.
>
> A comparison of the extent of item coverage by teacher type showed that control teachers covered more of the test's content than project teachers. This result was expected since the SPRSE curriculum is not well aligned with the state curriculum. Two analysis of variance were performed on both unadjusted and adjusted scores. The results did not show any statistically significant differences in mean scores between project and control schools. In conclusion, although examination of state test scores was important given accountability concerns in the state, they shed little light on the effectiveness of this project.

While standardized test scores do not tell whether or not the reformed science curriculum at Fairview is "effective," teachers and administrators at Fairview Middle School state that students like science more in classrooms using the SPRSE curriculum and felt they learned more.

The Issue of Assessment

Despite encouraging results on standardized tests and from the anecdotal evidence offered by teachers, the development of alternative assessment tools aligned with the curriculum to better determine the effectiveness of the curriculum has lagged behind other areas of the reform. To correct this deficit WSU obtained a grant to instruct teachers in various assessment techniques. The first in-service meeting on assessment was held during the spring of 1994--at the end of the data gathering phase of this study. Therefore, the results of this phase of teacher education are not documented in this case study.

Generally, assessment in classrooms using the new science curriculum varied with the teacher. Teachers' lack of confidence with creating alternative assessments parallels their lack of confidence with new teaching strategies. Most teachers gave traditional paper and pencil tests, although many were adding more open-ended questions.

Sara, the pilot teacher who has been with the project the longest, recognized the need for a different kind of assessment:

> Well, obviously if you're going to teach very differently, you're going to have to assess very differently. You can't work and do process skills types of learning activities five days a week, and then the next time they roll into class, hand them a strictly multiple choice kind of test.

Yet, teachers have one problem they wrestle with that inhibits their desire to try new types of assessments: the traditional grading system of the district. Teachers are required to give a percentage grade on student report cards. Many inexperienced teachers in the project have problems converting student activities and projects into percentage grades, so they often resort to creating worksheets, quizzes, and tests.

Their feelings of discomfort intensified when the teachers received a sample of the state standardized test. Their perception was that the test did not match the SPRSE curriculum. In response to the upcoming test, some of the teachers suspended the reform program and taught lessons from old textbooks for several weeks. They were concerned that their names would be published along with their student test scores, as was the policy in some districts, but not in the Lincoln County school district.

Some teachers have taken greater risks moving away from traditional assessment measures. Sara and Paul were two teachers who tried more creative, innovative approaches to assessment. For example, Sara took her class on a treasure hunt to assess their map reading skills. She gave each group a map to the treasure. If they found it, they received an A. Paul's students designed and performed an experiment, including collecting data and creating a report complete with tables and graphs of their own design.

Connie, a second year 7th grade science teacher, described how she assesses the students in her classes:

> When they do labs now I give them a grade on their responsibility, a combination grade of their responsibility, correct use of the equipment, working cooperatively. So that's an assessment that I do right then during that process. And then, of course, I still check papers, the information they turn in. I've always done group projects, and they do group projects now. I have devised more group project items that they do, and in doing that they are part of a group. They have to list or write their responsibility, what they did as part of the contribution to that. So it's the group assessment, but it's also an individual assessment.

The SERVE evaluation's survey of pilot teachers bears out teacher frustration with assessment. The survey indicated that 24 percent of teachers were either somewhat dissatisfied or very dissatisfied with their grading and assessment practices. Only five percent of the control teachers expressed any dissatisfaction with grading and\or assessment practices.

Although teachers often expressed confusion concerning student grading, students seem to have no doubt as to what they needed to do to make a certain grade. When asked, most students linked their efforts to a "good grade." A common student response was, "As long as I try, and do all my work, I'll get a good grade." Teacher responses were in agreement. As long as students made an effort they passed. Teachers at Fairview, who have implemented the reform to a large extent, said the only students who failed were students who did not do the work.

III. THE CONTEXT OF CHANGE

The one pilot teacher who has been with the program the longest stated her feelings about the reform and its future:

> ...And I do love the program. I'm very sold on it. I think it could really revolutionize science teaching and science learning, not only in this state, but in other states.

Yet, another teacher, who just completed his first year with the reform program, shared his plans for teaching science next year:

> I'll probably cut back on it (the reform program). I'll probably cut back. Well as you see here today, I've already changed my seating arrangement and that, alone, rather than having groups of four, having it more in rows with more pairs, really has cut down the noise in the class. ... Come back a little bit. Not abandon it, though, by any means. Don't get me wrong I enjoy it. The activities that we have and I conduct are very effective. They really are. But there's a lot of written material I think these kids are missing out on. And if we could, maybe, you know read a lesson, discuss the lesson, and then you say, "O.K., now let's close the books and we're gonna put it to use." Then you're not just memorizing but you see, "Oh, OK."

There is a dichotomy within the science department at Fairview Middle School as these statements illustrate. Some teachers think it is the best thing since sliced bread; others see it as an experimentation that might do students more harm than good in the long run. Very little has been done at Fairview to reconcile these divergent views of science education reform. Yet, at the classroom level the reform is teacher-dependent. The administrators of this reform make an important point that the reform is voluntary and that each teacher has the freedom to make changes and present the curriculum as she feels is necessary.

Yet, educational research reveals that the most critical factors for the successful implementation of a reformed curriculum are the teachers involved. Each practitioner brings to the classroom her beliefs about teaching and learning that she has acquired through her own years of schooling in addition to her philosophical beliefs shaped through her experiences as a teacher. Teachers, based on their beliefs, determine what the reform looks like in each classroom.

The teachers at Fairview Middle School come from diverse backgrounds and had different ideas of what their students' needs were and how to meet these needs. Some of the teachers come from an elementary background while others had experience in the secondary schools. Several of the teachers were teaching out of their subject areas and/or identify themselves primarily as a teacher of another subject, such as math. All of these factors contributed to the uneven implementation of the SPRSE curriculum in the science department at Fairview Middle School. Little had been done to address at the building level the effects of teacher beliefs on the adaptation of the reform in the classroom.

Recognizing the importance of teacher beliefs on practice and implementation, WSU constructed a two-week summer institute and follow-up procedures that attempted to address issues associated with teacher beliefs. The purpose of the institute was to:

- change teacher behaviors
- reduce teacher isolation
- decrease the rate of recidivism

The summer institute began with university coordinators collecting information from the teachers by using questionnaires about teacher attitudes and concerns along with informal discussions between the project staff and teachers, and letters to the teachers with open-ended questions regarding the reform effort and teacher concerns. While at the institute, the staff continued to monitor teachers' beliefs periodically during their two week stay while at the same time engaging the teachers in the activities structured to change their beliefs by comparing traditional teaching with teaching strategies that used a more constructivist orientation advocated by SPRSE project.

As a result, teachers had the opportunity to dialogue about the implementation of certain approaches to teaching and learning science. Coordinators of the workshops modeled these strategies for the teachers using active, hands-on demonstrations to make their points about effective instruction. For example, one workshop leader presented a science activity for the classroom where they made ice cream in baggies. The teachers loved it, and many asked about the details so they could do it in their classes. But when the in-service director asked them what really happened--what science concepts did they learn--no one can give him an answer. The point was made that what may look like a good activity on the surface may not be. He then presented the lesson again using the new curriculum framework and let the teachers see the difference.

In order to help teachers confront issues associated with differing teacher beliefs throughout the two weeks of the institute, the staff made a point of spending much of their time listening to the teachers and their concerns, as well as modeling appropriate classroom behaviors during staff presentations. The WSU Summer institute developers also helped teachers think about their individual perceptions of teaching science and the knowledge with which they believed students should leave school. Toward the end of the institute, university coordinators arranged for teachers to meet with scientists to talk about subject-matter issues as well as science education in general.

This approach to confronting teacher beliefs appeared to be somewhat successful. The teachers who attended the institute embraced the project in varying degrees. Yet, the most serious threat to teachers' enthusiasm and recidivism was the length of time that lapsed between the summer institute and the start of the school year. The institutes offered a unique opportunity for Fairview teachers to talk and think about their own philosophical orientation and how it corresponds with the new science curriculum. But many of them had not had an opportunity to practice what they learned at the institute immediately and may have reverted back to more comfortable teaching habits at the beginning of the school year.

Teacher Communication

The summer institute staff recognized the importance of teachers talking together and talking with them. Time and the vehicles for both oral and written communication among the in-service participants was provided within the structure of the institute. For example, teachers were asked to write letters to their instructors voicing their concerns and feelings about the reform. When the teachers returned to their classrooms they were given a phone number to call a university resource person anytime they felt the need.

During the first two years of implementation, teachers reported that they collaborated with other science teachers in their building, working and reworking the curriculum and various classroom activities. During the third year of this project much of this communication among science teachers had faded for several reasons. First, the normal attrition of the teaching staff had replaced teachers who knew each other and worked well together. The new teachers were strangers, who had classrooms physically distant from their colleagues and, being on different teams, their schedules contained no common time to collaborate. Second, increased demands on teacher time left little time for teachers to talk to each other. Fairview became an inclusion school which caused untrained teachers to wrestle with the additional burden of dealing with physically impaired students, such as blind and deaf students, as well as students with emotional and learning disabilities. The school also required teachers to teach interdisciplinary units which necessitated more collaborative time between team teachers of different disciplines. And third, the university was less visible and their personnel were less available because of funding cuts. They did not have the money to make trips to the school as they had in the past.

During this third year, teachers implementing the reform reported feeling alone or on their own. Teachers who had been engaged in SPRSE reported that they did not know what other science teachers were doing in their classrooms. Even during this case study, teachers would ask the researcher what their colleagues in other classrooms at Fairview were doing.

Teacher Ownership

Teacher beliefs influence the extent to which teachers feel ownership of a new curriculum. At Fairview, despite being a school with site-based management, teachers felt varying degrees of ownership of the new science curriculum. Many factors within the larger school culture and social context affected their sense of ownership, which in turn affected their willingness to employ new teaching strategies and content. The following teacher profiles illustrate some of the tensions associated with change at Fairview.

Sara Miller is a pilot teacher who had been with the project from the beginning. She, along with a colleague who has since moved to a different area of the country, helped write the 6th grade curriculum. She continued to try new activities and rewrite the curriculum, even in the third year of implementation. Others in the school, and even in the district, looked to her as the leader of the reform program. She characterized herself as a teacher who likes to try different things:

> I embrace change. I like when things don't stay the same I'm always looking for something that makes me better at what I do, that gets it across better to my students. That makes them more excited about science.

She said she found the project exciting and committed much time and effort both to the program in her own classroom and to the whole project. She worked closely with the university and was involved in the summer training institute and meetings throughout the year. Her classroom was a model for the project and she was often video-taped for presentations to other faculties, researchers, and other interested parties.

She said she believes in the philosophy of the project and felt that even if she went to another school she would teach according to the principles of SPRSE. Next year she takes on new responsibilities as the district resource person in math and science. She hopes that she can make an impact and help teachers at other schools implement the reform program.

Michael Berman is a first year teacher who majored in physical education. During his relatively short time in the classroom he has established excellent rapport with his students. They sincerely liked being in his class and were eager to share their lives with him. He was always seeking ways to make science more meaningful for his students. While being interviewed during an early visit to the school, he said that he liked the project and that both he and his students were finding science fun.

As the school year wore on he began to have doubts. He said that it seemed that they were always doing activities but that the science reform lessons did not conform to his view of science. He also had a difficult time justifying the grades he gave his students and felt the need for tools to grade his students more objectively. To fill this need he began creating his own worksheets, quizzes, and tests.

Several times he commented that he would feel more comfortable with a textbook. In addition he related his feelings that the project went too far. He stated that maybe the project "should come back a little bit and be more in the middle of the road. There could be a little less activity and more substantive material." He also found that teaching the project required a lot of time. Project demands compounded with his coaching responsibilities made his first year of teaching difficult.

During a later visit during the study, he felt more positive about the project. He said that he felt more comfortable with some clusters (units) than others, because, "some are just better written."

Taylor Davis is an energetic and enthusiastic 6th grade teacher who is relatively new to the profession but is involved in many aspects of the school. Although this is her second year teaching, it is her first year on the project. She described herself as "a computational math person" but also has shown creativity in student activities and assignments.

She taught 8th grade science last year when it was a textbook-based program. At the beginning of the year she, like Michael, was very excited about the project. She often expressed her own satisfaction, and some amazement that the students knew certain things--such as the fact that Neptune is further from the sun than Pluto at this time--a fact that her previous 8th grade students never seemed to remember.

But as time worn on, her enthusiasm for the project had waned, especially after a parent confrontation where she was put in the position of defending the project and justifying a student's grade. She did not feel adequately prepared to do either. Since then she has generated some of her own written materials in order to grade students more objectively.

Both Michael and Taylor did not have the same feeling of ownership as the original pilot teachers. They relate that they were just given a curriculum package to follow, but they do not feel so constrained that they cannot modify or change what they do in class.

Paul Campbell and Connie Marshall are 7th grade teachers who joined the project the second year. They had worked closely together to write the 7th grade curriculum and their teaching had evolved along with the project. They both continue to make changes as they try new ideas:

> Well, through the year Paul and I worked really closely together on, we would discuss the lessons, and I might try one thing, he might try another. We both might try the same thing, and we'd discuss what we thought worked, what we felt like we needed to put into that.

Connie stated that she and Paul had a good working relationship because they were two different kinds of teachers and were able to draw from each other's strengths.

Both of them saw the dialogue or the verbalization with the students as the biggest and the most important change in the reform process. The questions asked of students are now oriented to guiding the student to make his/her own sense of observations instead of regurgitating textbook facts.

These three teachers, Sara, Paul and Connie, felt they had "ownership" of the program and were comfortable making changes because "the curriculum was written by teachers just like me...in fact, I was one of the teachers." They also had classrooms in close proximity to each other, which facilitated collaboration. Most of the collaboration occurred between the two 7th grade teachers because they were teaching the same curriculum.

Diane Edwards is an experienced teacher in the first year for the 8th grade program. She is a teacher who had taught gifted students and computer lab at Fairview for eleven years. She described herself as a teacher who kept abreast of changes in education by attending conventions, reading professional journals, and incorporating new methods into classroom instruction. She felt she made the change from a teacher-centered classroom to a student-centered and activity-oriented classroom prior to participating in SPRSE. So when she was asked to teach the science reform program, she felt it would be a continuation of what she was already doing.

On observation, she was using the reform curricular materials and hands-on activities in a very controlling manner. She walked her students through the activities step-by-step, telling them what to do and then checking their results. Student decision-making and student engagement in group discussions was absent from her classes.

She explained her classroom procedure by saying that a very structured and controlled lesson was necessary to establish the procedures and get the students into their roles. According to her, the students had not worked with chemicals, heat, or glassware during their previous science classes, so she felt that extra control was necessary. She explained further the need to establish order before letting the students work independently.

In later discussions, Diane stated that this year was the "worst year" of her teaching experience. She felt the composition of the student population along with the extra demands of SPRSE and a number of other concurrent school changes created a difficult situation. One major problem--in her opinion--was the fact that only one-third of the curriculum was written before beginning this school year. She felt she had to complete the school year totally alone, trying to write curriculum while teaching.

She said that she would continue to work on a curriculum that is consistent with the philosophy of the reform program and was looking forward to a better experience next year, hopefully, with a more developed curriculum.

Linda Sandwell, the other 8th grade science teacher, has been teaching science for fifteen years. She has a genuine concern for the students in her charge, takes her responsibility as a teacher seriously, and feels an obligation to prepare them for the future.

At the onset of this investigation she was very open and honest concerning her reservations with the reform project. She felt that she has been doing a good job and did not see anything wrong with her teaching. In fact, she worried that the reform project may be treating the students as "guinea pigs" and ultimately doing more harm than good. She also related that she has seen reform projects "come and go. Every time there's money for a project, people jump on the band wagon, but when the money's gone, so is the project." Despite this she was willing to give this new reform program a chance.

The amount of science content was an issue for Linda. She felt that there were some things that the students had to know--like the symbols for the elements--and the only way to know them was to memorize them. She was also uncomfortable with the "spiraling" of the reform curriculum. She felt that covering a topic in more depth once was more beneficial than revisiting the topic several times. Another area of discomfort was splitting the science disciplines through integration. She preferred to cover all astronomy topics, then all geology topics, etc.

For most of the first semester Linda adhered to the new curriculum. Her students worked in cooperative groups and used many hands-on activities. During later discussions Linda stated that these activities were not new to her. Her class engaged in such activities prior to this new reform program.

During classroom observations, it was noted that many hands-on activities seemed disconnected and that classes often ended with the students copying notes from the overhead projector. Linda explained that making connections between content and the activities was a problem for her. She felt that the "spiraling," caused connections to be forced. Her discomfort with the project and concern that students were missing important science content caused her to revert to giving notes on the overhead.

In December, Linda reported that she had "used up" all the SPRSE curriculum. Therefore, she was going back to her original teaching methods and reissued textbooks. But she stated that the purpose of the textbooks was to serve as a guide. She would still use cooperative groups and hands-on activities.

When asked about her plans for next year, she stated that it depended on what was done with the 8th grade curriculum in the coming summer. If it was revamped, she would try it again. Otherwise, she was going to teach as she always had, but keeping some of the better ideas from the reform. She went on to say that every time she is involved in a new project, she gathers a few more ideas and incorporates them into her teaching--even when the project is discarded.

Despite having been "teacher written," many teachers did not seem to feel a particular ownership of the reform curriculum for a variety of reasons. For the long term teacher like Linda, teacher beliefs and philosophy about science content put her at odds with the curriculum, although she chose to retain a few ideas from the new approach. The natural attrition of personnel necessitated the addition of new teachers, like Michael and Taylor, who had no way of being incorporated into the group of original pilot teachers. As teachers who participated in the original curriculum writing and development left Fairview, they were replaced with new teachers who did not have the same commitment to the new curriculum as the original teachers nor an understanding of the principles and philosophy of the reform project.

Somehow these new teachers had not been "brought into the fold." Department meetings, communication networks or planning meetings among science faculty were not in place to help solve this problem. The larger context of the school did not support a change in teacher beliefs or behavior.

Administrative Support

At the school level there were some anticipated personnel changes that teachers feared would change the culture and context of the school as well as place the SPRSE curriculum at risk. Fairview's supportive principal had accepted a district position and had been replaced by the assistant principal, at least temporarily. The permanent appointment is not known. Sara, the unofficial leader of the reform, was preparing to leave to assume district duties and her successor was not known. Several other teachers indicated that the reason they were teaching at Fairview was the supportive administration, especially the principal. With his leaving, it is possible that there may also be changes in the staff. The future of the science reform depended on the administrative personnel who would be replacing the key administrators who supported and nurtured the reform initiative at the school.

District Support

The district basically had a "no interference policy" for the implementation of SPRSE. Because of their site-based school management, if a school administration and teachers wanted a program they supported that decision. District personnel showed their support by helping the school and University obtain Board approval for the implementation of the science reform project.

After observing classrooms using the new science curriculum, district personnel became convinced that the techniques and strategies used in the program could be beneficial to other schools and programs as well. Therefore, they encouraged other teachers throughout the district to become involved in the science reform to learn the various techniques used to facilitate student learning. District leaders hope this sharing would indirectly facilitate change within the district.

Despite the district's endorsement of the new curriculum and its new teaching strategies, district support was weakened by the policy of requiring teachers to give percentage grades to students as well as the yearly standardized tests mandated by the state. Many Fairview teachers saw the misalignment between the new science curriculum, standardized tests and increased teacher accountability as a sign of low support for radical change.

One weak link between the district and Fairview was the district curriculum director for the middle grades. She rarely acted as liaison between the science teachers at Fairview and the district because she was "spread thin." Her responsibilities included all the disciplines for all of the district's middle schools. She participated in three organizational meetings for the SPRSE initiative at different locations around the state each year and attended science department chair meetings in the district. She said she saw her role as communicating the shared successes of the project throughout the district and keeping principals informed of the resources available to them to continue reform efforts. For example, at a recent meeting of middle school principals, she announced that any science teacher interested in being trained in the SPRSE program was eligible for the summer institute.

Plans for next year include the creation of a science-math coordinator position to provide more assistance for teachers making change in the classroom.

University Support

Western State University (WSU) and Eastern State University (ESU) provided key support for SPRSE at the state level: Co-directors of the Project; Curriculum Director; Director of In-service Education; and staff for the summer institute. Besides their official duties administering the project, the faculty at WSU was involved in working hard at the building level to encourage teachers and to offer them technical assistance throughout the school year.

The main support structure the two universities offered the staff at Fairview Middle School was on-going teacher education and training. The cornerstone of the teacher education process was the two week, in-service institute that addressed prior teacher beliefs and introduced the teachers to the principles of SS&C. Follow-up visits to the schools, phone calls, and a newsletter function to support the efforts of the teacher as he tries to implement the project into the classroom.

The teachers felt that WSU was supportive and that they could turn to them when needed, but they also recognized the limitations of time and money:

> WSU has stood by us. They have, even when funding has, even though it's come to an end, they have said, "We will be there. We are committed to this."

The key person in this process was the director of curriculum development. All of the teachers identified her as their motivating force in implementing SPRSE at Fairview. They have nothing but the highest praise for her efforts: "isn't she wonderful!;" " she's always so positive;" " she makes you really want to do it." Teachers felt she communicated effectively with the them and gave them encouragement when needed:

> But as for the university, WSU, the people there have always been very supportive and very interested in what we are doing. And Ann is so inspiring! I wish we could see more of her but she's, you know, very busy and has her own teaching responsibilities.

WSU's major responsibility included conducting the summer institute for teachers new to SPRSE and also providing teacher support during the school year through the use of state-wide meetings and school visits. Due to tight financial constraints the past year, there were only three meetings and two school visits. The curriculum director for the project states that, ideally, she would like to visit each school once a month but was unable to do so.

The prime responsibility of the other participating university, ESU, was to develop the technology to support the project. As of June 1994, the teachers report they had received no technological support from ESU. Many of the them related that they felt abandoned or resentful because they had computers they could not use:

> But we have no software to go with these computers that are sitting in our classrooms. So it's frustrating.... when this project started, it was suppose to be a cooperation between Western State University and Eastern State University...We've gotten no in-service on how to use the computers we have. And we've gotten, well, nothing.
>
> ... the SPRSE project supposedly was going to be very big on technology. ESU, which had part of the grant, was in charge of the technology. You'll see the two computers that, Lincoln County agreed to provide as part of their commitment to the project...and

> we got two computers per classroom. ESU was suppose to offer the support in terms of training. I've received none of it.

In addition to offering teacher training and education, the universities also contributed to the program's financial support in many ways. University personnel wrote proposals for funding to continue teacher in-service education and to expand participation in the project within the state. Recently they received a grant to improve assessment in the project. As a result SPRSE teachers attended the first assessment in-service program in the spring of 1994.

State Level Support

The state also contributed to the larger context that influenced what teachers did in the classroom. While the current science curriculum was state initiated, teachers were still ambivalent about state support for science education reform. Many saw the state testing program as a factor that might undermine reform efforts. University personnel had begun working with the state department of education to make a new test which matches the restructured curriculum. But the last estimate was that it would take at least two years before a new test would be available. In the meantime, the old assessments would be in use. This situation caused more than a little anxiety on the part of teachers. They were uncertain of the consequences if their students scored low on the state test.

A second factor that caused anxiety among science reform teachers was the release of new state curriculum guidelines in April 1994. Although they were broad, several teachers had interpreted them as not being aligned with the SPRSE curriculum. They felt that they would need to rewrite the science curriculum to match these new guidelines. They did not relish this additional burden.

Summary

Educational reform, whether in science or some other area, is difficult and requires much hard work and commitment on the part of the participants. Even harder is maintaining the reform after the initial enthusiasm has waned--for then it becomes just a lot of hard work that requires enormous amounts of time.

Rather than being secondary influences, the larger contextual factors outlined in this section play an important role in determining how comfortable teachers feel in incorporating new reform strategies into their classroom practices. The next section will look more closely at the implications for change learned from Fairview's experience.

IV. CONCLUSIONS AND IMPLICATIONS

The primary purpose for reforming education is to better educate the students in our nation's schools. The impetus for change is a perceived deficiency in the achievement and\or attitudes of the youth in our classrooms. According to school officials at this particular site, the change from a junior high school to a middle school shifted their focus from a disciplined-centered orientation to a student-centered philosophy with an interdisciplinary approach. This change created a need for a different science teaching strategy that put the students at the center. The current question is: how well has the science reform filled this need?

The acid test for any reform is to look at what has changed for the individuals involved. Is what they are doing really different from what went before? Once this question is answered then the next question is: Are the participants deriving any benefits from the changes, and are the benefits worth the costs involved? Looking at the key ways science has changed for teachers and students can help answer that question.

What Has Changed for the Students as a Result of Science Reform?

Students view science more positively. One area of agreement for teachers, administrators and the students themselves is that students view science in a more positive light after engaging in SPRSE classes. They no longer see science as forbidding or "just too hard." They make comments that "science is fun" and, in some cases, exciting. Students in increasing numbers are rating science as their favorite or one of their favorite classes. Teachers relate anecdotes of student displays of disappointment when science class does not meet, and teachers new to the reform are often targets for students' disapproval when they decide not to engage in SPRSE.

Science is no longer presented as separate disciplines but as an integrated body of knowledge arranged around major themes. Connections rather then the separation of the traditional areas of science are stressed. Students are given an opportunity to engage in problem-solving activities with other students and to verbalize their own reasoning as they go through the process.

The primary benefit to students has been an increased sense of competence regarding their ability to understand science concepts. More students are viewing science as "something they can do" and even as a career possibility. As a result, increasing numbers of students are applying for enrollment in the advanced physical science course and parents relate stories of students "doing science" at home with their families.

Currently there is no good assessment tool to gauge whether this new sense of competence has translated into better student performance under the new reform. But indications from the old standardized tests are that students are doing at least as well as they did in traditional science classes. Anecdotal evidence from teachers indicate that student enthusiasm has translated into improved achievement.

Science is perceived to be for all students. In the sixth and seventh grade science classes, all students regardless of physical, emotional, or mental impairments can be seen participating in science activities together. The SPRSE curriculum has de-emphasized tracking in which some students get a watered down science curriculum. Even special education students have been included in SPRSE classrooms. Blind and deaf students along with learning disabled and seemly normal students work in groups together, explaining and helping one another. The one exception to this pattern occurs in eighth grade when gifted students are removed from SPRSE classes to take an advanced physical science course.

Eliminating tracking in science has increased pressure on students to develop better communication and collaboration skills in order to work within groups composed of students of different abilities as well as greater cultural and socioeconomic diversity.

Students take on more responsibility for their own learning. At this site, students take a more active role in the classroom and have increased responsibility for their own learning. Rather than passively listening to lectures, they are asked to willingly engage in designing and executing experiments to solve problems. Instead of relying on one textbook for information, they research topics from a variety of sources and construct their own textbooks in the form of a journal.

Taking responsibility for their own learning has benefitted students by helping them make sense of how science can be applied to real life. The cost has been some discomfort and tension in teacher-student relations because students must make a paradigm shift regarding teaching and learning; they experience some discomfort and resistance as a result of change. This change is in addition to the high level of physical, intellectual and social change already experienced in the middle school years.

What Has Changed for Teachers?

In the previous section we summarized, in general, the cost and benefits to students as a result of their participation in this reform initiative. Now we turn our attention to teachers. Teachers play a key role in how SPRSE is enacted in the classroom. But the degree of change varies from classroom to classroom. Despite this variance, there are several changes teachers have had to face. Have teachers, too, benefitted from the changes in the science curriculum at Fairview, and are those benefits worth the costs involved?

Teachers are required to make fundamental changes in pedagogy, classroom roles and beliefs. Even though SPRSE is voluntary at Fairview, if a teacher engages in the reform she must make a great number of changes, from classroom organization and management to teaching pedagogy. The teacher's role in the classroom changes from being the primary giver of information to that of coach or facilitator. In order for reform efforts like these to be successful the teacher needs to give students the freedom to explore, to work with other students, and to give them the chance "to figure it out." The research literature on teaching suggests that there is great benefit to the students *and* teacher when the teacher's role shifts. Learning is actually easier to facilitate because the student is the worker. Critical thinking and problem-solving increase when the teacher facilitates learning rather than transmiting a discrete set of facts through lecturing.

Yet, the cost of this type of change in teacher roles is high. Professionally and personally, many teachers seem to have a problem shifting roles, feeling that they are giving up control of their classroom in the process. Teachers who have been teaching the same way for many years, or who do not have the depth of subject matter knowledge, often struggle with such an approach. Trying to make the transition from transmitter of knowledge to facilitator of knowledge under these conditions is very stressful.

Teachers' beliefs concerning science, teaching, and how students learn also need to be changed. SPRSE presents science as a dynamic process for discovering our world, rather than an encyclopedia of facts. Problems have arisen at this site because teachers have a difficult time "letting go" of their static view of science as facts to be known and committed to memory. In conjunction with this view of science, teachers often equate teaching with telling and learning with memorizing. These beliefs are inconsistent with the successful implementation of the science reform project. One result is teacher frustration among some teachers.

Along with the changing teacher role is a change in teaching strategies that many teachers find difficult because of a lack of expertise. Most teachers report that preparation was in a traditional setting where the primary strategy was lecture and the students worked quietly alone. First attempts at cooperative learning, student verbalization, and hands-on activities are often met with frustration. Additional skills in classroom management, management of science materials, and patience are needed to transform a traditional classroom into a classroom using teaching strategies based on current education research.

Time needs are tremendous for teachers involved in change. It has been said, "Change is hard!" It is especially hard for the teacher who must make vast changes. These changes take enormous amounts of time for training, meetings, collaboration with peers, writing curriculum, and preparing for class. Most often this time is donated with no financial or reciprocal time reimbursement.

Yet, teachers are expected to make these donations of time in addition to already heavy student loads, site-based management demands, committee meetings, and other school mandated requirements. This has been the cost of change for many teachers, not enough time in the school day to nurture the new relationships within or outside the classroom.

Other Implications

There is a need for continued teacher learning. The summer institute sponsored by WSU began the process of challenging teacher thinking and demonstrating to teachers an effective alternative to their current science teaching. The problem is that two weeks is insufficient to bring about real and lasting change. After the original inservice education teachers need guidance and support as they enact the new curriculum and strategies in their classroom. As problems arise there needs to be someone to help work out the "kinks", to make suggestions, and sometimes "just to listen." If no one is there, the teacher reverts back to what is comfortable. Permanent, inexpensive opportunities for on-going teacher support and education are needed to bring about long term change.

There is a need to create permanent communication networks within the school building as well as across school buildings. There is also a need to have time built in the schedule for teachers to get together. At Fairview, science teachers had team planning time to talk with teachers of other disciplines but there was no time for science teachers to talk. This lack of opportunity did two things: it deprived teachers an opportunity to model cooperative learning and collaboration for their students and it reinforced the isolation teachers often feel in the classroom. Breaking down the walls of isolation teachers experience is crucial to successful reform. Change is hard. It needs to be nurtured and supported. Communication networks provide teachers with the opportunity to share ideas, problems and to give much needed moral support.

Better alignment of school, district and state assessments are necessary to sustain change. In order to reinforce change in the classroom, the acceptable measures of success must also change along with the curriculum. Except in rare instances, students are still held responsible for knowing science vocabulary and a body of scientific facts. Report card grades are given in percentages which are largely determined by traditional paper and pencil tests. Most tests have an objective format with a few open-ended questions added at the end. These sorts of traditional assessment tools are incompatible with a hands-on, problem-solving oriented curriculum.

The greatest danger is that teachers and students are sent a conflicting message about what is important. Students are exposed to a variety of experiences where they have an opportunity to engage actively in the process of science and verbalize their interpretations. While at the same time teachers are sending the message that what is important is a set of facts or vocabulary by ending class with "facts to know" on the board and testing students knowledge of "facts."

Alternative student assessment needs to take the place of traditional student evaluation. Teachers need to know what their students understand and when deficiencies need to be addressed. Objective tests often fall short of this goal.

Shifting local, district and state contexts put reform at risk. All participants in reform efforts need to stabilize external contextual factors to allow change to become deep rooted. Currently the state is in the process of writing science guidelines and constructing new standardized tests. The first drafts reviewed by SPRSE teachers have raised some concern about the alignment of SPRSE content with state expectations.

Changes in personnel at Fairview and at the district level raise questions about continuing administrative support for the science reform project and hiring teachers who will continue the work begun by their predecessors. New teachers often express discomfort with someone else's material. These changes coupled with declining university support due to funding cut-backs are viewed as serious threats to the future of the science reform project.

Schools must create self-renewal mechanisms in order to maintain the reform after enthusiasm wanes and funding declines. One of the most critical problems is maintaining the reform after the original enthusiasm has waned and funding has declined. As new personnel take the place of teachers and administrators who have "moved on" the commitment to the reform project is in jeopardy. Other factors, such as the action of state legislators, standardized tests, and teacher accountability may work to undermine the efforts of the original reformers.

Schools must create mechanisms within the school culture as well as within the system to allow change to prosper. If reform efforts are dependent on a small cadre of teachers within the school, personnel changes may undermine the spread of the effort. Schools must become "learning organizations" so they become immune to fluctuations in enthusiasm or funding.

The Future

The future of the State Project for Reform in Science Education is uncertain at Fairview Middle School. Currently the reform looks different in each classroom--depending on the beliefs, expertise, and demands of each teacher. Therefore, each teacher involved has differing needs for support and further education. In addition there are many outside forces exerting influence on the teachers and the school which tend to undermine their efforts at reform. Large scale changes are still needed which require a long term commitment from the administration and the teachers.

Although the future of SPRSE is questionable on the large scale, there will be significant lasting changes for many teachers and their students. Teachers who have embraced the change report that they will continue to use much of the reform--even in another setting. Even teachers who have opposed SPRSE identify desirable aspects of the reform that they will continue to employ in their teaching. In addition, students have gained a more positive view of science and themselves in the process.

COORDINATED SCIENCE AT WESTVIEW HIGH SCHOOL

RONALD D. ANDERSON
UNIVERSITY OF COLORADO

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This paper was prepared for the Curriculum Reform Project, a study of curriculum change in mathematics, science, and critical thinking which is funded by a grant from the U.S. Department of Education's Office of Educational Research and Improvement (OERI Grant #R91182001). The opinions expressed herein are those of the author and the participants in this study.

FOREWORD

When faced with a challenge, a detailed story of someone else's experience in a similar situation generally is of strong interest. In reading someone else's story--be it political history, a chronicle of dealing with a family tragedy, or the story of a major business success--we do not expect to find a formula to apply directly to our own situation; instead we hope to find insight and inspiration. Thus, the story contained in this report should be engaging to individuals committed to educational reform in a local school context. It is the story of one school--or department within a school--engaged in fundamental reform of education for its students.

Similarly, one should not expect to find in this case a model for a specific educational reform to initiate in another locality. Every context is different. Each local school and community culture has its distinctions, each individual's and group's educational goals have different shadings, each setting has its own history, and each school has unique constraints to making change.

Not only does one formula not fit all schools, there is no specific formula for a given school. A central message of our case studies is that educational reform is a long-term process for which there is no detailed road map. It is an uneven process with highs and lows, failures and successes, but gradual movement toward greater and more profound learning for students.

What we can expect to find in this story are insights about new teacher roles, how students go about learning with greater depth of understanding, the context in which such shifts can occur, the challenges that must be overcome to initiate these changes, and actions taken by various parties to keep the process of change moving forward. Reflecting on someone else's story can be helpful in the process of developing one's own plans, collaborating with others to move the process forward, and helping students take responsibility for learning.

The Research Project. The case study reported here is one of nine--three each in science, mathematics and higher order thinking across the disciplines--conducted as part of the Curriculum Reform Project. The cases were studies of individual schools--actually a department within a school in the case of science and mathematics--in the process of solidifying reform. Each was selected because it was a successful example of reform. A researcher spent 20 or more days at the site to learn what changes they were making, the barriers encountered, how they overcame these challenges, the nature of their successes and their hopes for the future.

Site Selection Criteria. Sites were sought which had initiated reforms consistent with those recommended by leading groups in the respective field, e.g., the Curriculum and Evaluation Standards for School Mathematics (Commission on Teaching Standards for School Mathematics). Final selections were based on program outcomes including student test scores, enrollments in subsequent elective courses in the given subject area, and professional judgments about the quality of the curriculum provided to students.

Site Selection Process. The search process began with the solicitation of nominations from researchers and knowledgeable practitioners across the U.S. Key people at the nominated schools were contacted by phone to get additional information and written exchange of information followed. Selection according to the above criteria resulted in schools spread across the country with considerable variation in location (e.g., urban vs. rural), economic level and ethnic makeup of the communities.

Research Methodology. In each case the researcher was immersed in the activities of the school and collected a wide range of information. Data included classroom observations, interviews with students, teachers and administrators, and a variety of documents from the site. The voluminous field notes and interview transcripts were analyzed and an interpretative report written.

Cross-site Analysis. A cross-site analysis of the nine cases was conducted to gain perspectives that extend across the sites. An individual case is rich in description and context but does not contain the depth of analysis that can come from looking across a number of cases. Thus, the reader is referred to the Project's cross-site analysis. Main points from this analysis to bear in mind while reading this one case, however, include the following:

- The reforms being sought are profound and demand major changes in teacher and student roles.
- The process for achieving such reforms is complex and demands a long period of time to attain.
- The schools in these cases have traveled a considerable distance on the road to reform but have not yet "arrived."

These cases are presented largely--though not exclusively--from the perspective of the teachers at the center of the cases. This perspective reflects the nature of the reforms and the way they have been initiated in each school. This perspective may be particularly important for initiating change. Our cross-site analysis shows that changes in teachers' values and beliefs--not just greater teaching skills and techniques--are central to reform. While changes in student roles and student work are the ultimate "bottom line," these teacher changes are an important intervening step.

We hope your reading of this case stimulates both interest and significant reflection about reform activities in your school.

Ronald D. Anderson
Director, Curriculum Reform Project
University of Colorado

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I. INTRODUCTION

The science department of Westview High School has developed an integrated science program in which students study aspects of biology, chemistry, physics and earth science each year, rather than devoting separate year-long courses to one field. Known within the school as Coordinated Science, the program is now completing its fourth year of operation. Three years of integrated science are now available to any given student at Westview High School. The development of this program has been influenced by the National Science Teachers Association's Scope, Sequence and Coordination Project and guidelines contained in the extensive California Science Curriculum Framework.

The Coordinated Science program got its start at Westview when Karl Tozer, the science department chair, responded to the winds of change blowing down from the state and national levels regarding science education reform. The program was initiated and developed by the teachers with little school or district administrative influence, other than that of their elected chair. A new high school science program took shape in which subject area boundaries were broken down, science was studied in a more integrated fashion, students did more laboratory work, and more connections were made between the science knowledge and its various applications.

This case study report is the story of Westview High School science and the people who developed and operate it (all place and person names are pseudonyms). The Westview story is not about a group of experts showcasing an ideal model; it is about the work of "regular" teachers in an "ordinary" school, subjected to the influence of forces of reform coming through routine political and professional channels. The case study includes a description of the program, its outcomes, the process by which it evolved, the issues and dilemmas currently faced by the participants.

Program Outcomes

An initial question is whether there are sufficient changes at this site that make it worthy of study. Does the new program result in greater student learning? Is the depth of understanding greater? Do students have a greater interest in science. Such questions are not always easy to answer, but they deserve careful attention.

Coordinated science compared to standard science. Discussion of Coordinated Science inevitably leads to comparisons of student performance with that of students in conventional programs. Although student performance on standardized tests is the conventional means of addressing this question, answering the question in this manner is not as simple as it appears on the surface.

When this topic is discussed with Karl, he points out that they have made such comparisons using conventional tests and their students compare very favorably with students in the regular science program. He also notes, however, that the tests used for such comparisons are not viewed with much favor anymore within this district of approximately ten high schools:

> The district doesn't give that test anymore because everybody agreed it was the wrong kind of test to give. I mean everybody. It was universal; all the science chairs said why are we giving this test? It is not testing what the Framework says. It is not testing what everybody is supposed to be testing, so we are not going to give it.

Under procedures instituted this year, the tests will be different but this change does not remove a fundamental issue: Does the test reflect the curriculum, and if so, does it reflect a different curriculum to which one wishes to make comparisons? In an extension of the above discussion, Karl noted that, in essence, he was saying that their students will do comparatively well on any test that really is a reflection of the content they happen to have in their course. He carefully points out the difficulty of knowing how well students are doing in Coordinated Science versus some other course as measured by a test, because the test results reflect a particular curriculum balance as much as how well the students are performing.

Tests also can vary in the nature of the content tested, such as the use of content in a hands-on, "real world," laboratory context versus "paper-and-pencil" information. Karl elaborates:

> If you give a performance test every one of our kids, not just the college prep and honors kids, will do well because they do all the labs. Every kid does the lab; they can't get out of it. In a typical earth science class (in a regular program) they do worksheets and very little laboratory experiments.

These conversations with Karl about comparison of programs are indicative of the dilemma most people face in making quantitative comparisons of innovative programs. It is important to note that there are many considerations that enter into relative performances. As a result, it becomes very difficult to make direct comparisons in a rigorous research mode; there are many differences from one place to another, e.g., in terms of class size, the character of the school populations, and the coverage of concepts.

Comparisons of the Coordinated Science Program at Westview with the traditional program by means of conventional testing have been favorable. Such comparisons involve substantial difficulties, however, and are not the easy source of definitive answers so commonly thought. The Westview science department plans for additional comparisons of this nature, but has no illusions about definitive answers from them.

Nature of the science learnings in the Coordinated Science Program. The Westview teachers are not satisfied to make comparisons only on the basis of standardized tests. They have important perceptions about the *nature* of the content students are learning in the Coordinated Science Program. Julie Owens, for example, is convinced that for her Coordinated Science students, their "understanding of things happening around them is much better," and they are "better able to apply ideas from one situation to a new one," and they are "a lot more open to trying different things." Other teachers expressed this qualitative difference in similar language.

Betty Cronin referred to the students as being more "reflective," and Dave Vaughn is convinced "their thinking skills are getting better and better." In her analysis of the situation, Julie said "I think that they are better at drawing conclusions and seeing similarities, dissimilarities than other groups" and she is convinced they are better able to "apply that knowledge in a new situation."

The following year Julie began teaching in a different school within the same school district, but had similar opinions. The student body of the school to which she moved is very comparable, but its program is of a conventional nature in contrast with the innovative Coordinated Science program of Westview. In comparing the two and reflecting on her enthusiasm for the Coordinated Science Program, Julie said, "Actually it has increased my enthusiasm for it, because I see now a comparison." She went on to talk about the difference in the writing skills of the students in the two contexts and the student-teacher relationships:

> They build on those skills each year the way we have planned, and I think it really does give them a much better handle on science. But their math skills are probably better because we reinforce more of the writing skills, their speaking skills, their presentation skills as we try to build some of that in. I think all around they are coming out better students, higher achievers.

She made further reference to students' ability to make connections, and the fact that the students exhibited better behaviors and a better understanding of teachers' expectations for them. All these factors were intertwined with the fact that teachers got to know the students better and learning was more fun for both students and teachers.

The applied nature of the science content and the emphasis on connections between various facets of science knowledge are important to the teachers. Linda is persuaded that information is more up to date as a result of this Coordinated Science context.

Another clear indication of the success of the program is increased enrollment in science. In addition to the fact that many more students are choosing Coordinated Science over the traditional sequence, students overall are taking more science at Westview than they did in the past. This situation is clearly reflected in the enrollments for a third year of science. Only two years of science are required of all students, and considerably more students are now taking a third year of science than in the past. The program is popular and one result is increased enrollments--a fact noticed by the school administration. While emphasizing that "we are definitely reaching more kids," Karl is quick to point out that they are doing more than meeting the needs of college bound students. The increased enrollments are indicative of the fact that they are spreading the net more broadly and bringing a more diverse group of students into a successful science experience. One goal of science education reform is to increase science education *for all students*; in this regard, the Westview Science Program has clear indicators of success. This increased enrollment is tied to the fact that students at Westview find science interesting and they enjoy the classes.

Now we will examine the factors that contributed to this success.

Data Collection

The data for this case was acquired during more than 20 days on site observing classes, interviewing students, teachers, and other personnel, and collecting a variety of materials for later analysis. Immersion in the site was followed by even more time-consuming analysis of the collected data, and subsequent writing of the results of the analysis.

The Site

Walking the school pathways with students and teachers at Westview, one gains the impression of a typical California school. The word campus is an apt descriptor of the physical setting itself; it is a landscaped hillside with a collection of one story separate buildings in which the main door of each classroom opens to the out-of-doors. The walk from class to class, even if it is the classroom next door, is outside. The sidewalks to which these doors open extend along the side of each building and between buildings. Large roof overhangs and covered walkways between the buildings enable students to proceed from one class to another without getting wet even in the midst of the occasional rain shower. Thirty three years old, the physical facilities give the impression of being well kept but not unusual in terms of design or special features. The general image conveyed by the physical facilities would fit literally hundreds of California secondary schools.

The physical facilities for science instruction are not in any way exceptional; in fact, they might be described as somewhat substandard in that not all of the classrooms used for science have either laboratory facilities or the requisite equipment stored in or immediately adjacent to the classroom. The rooms used for science instruction are scattered among three different buildings. One building has two laboratory equipped classrooms next door to each other, a second building has another of the science classrooms (without the usual laboratory facilities) and a third building further away has yet additional science classrooms. This third building has two laboratory equipped classrooms adjacent to a storage and preparation room. At the back of one of these two classrooms is a small office which is used by Karl, the department chair. At the other end of this third building is yet another classroom used full time for science but without the normal laboratory facilities. A portable demonstration table on wheels, including a sink with water tank, is the centerpiece of its science facilities. Movable two-person tables with individual chairs are used for both hands-on laboratory type activities and other classroom work. In this same building is a tiered room large enough to hold the students from two conventional sized classes which apparently was designed for the use of the science program when the school was build, but was long ago taken over by the theater department for its instructional purposes.

School Context

Changing demographics. As in many places, the demographics of the student body are changing and reflect a gradual increase in the proportion of the student body who are ethnic minorities. In the mid-1980s Westview High School had approximately seven percent minority students, with most of them being Hispanic. As of the 1993-94 school year the percentage of minority students at Westview was forty percent, with the largest group of minority students being Hispanic, the next largest Asian-American and the next biggest African-American. The majority of the students are headed for some form of post secondary education, although the faculty describes the percentage of students headed to elite ivy league schools and the prestigious University of California system as being relatively small. The majority of students are headed to the California State University system and community colleges, with some planning to attend other more vocationally oriented post-secondary education.

The change in demographics of the student body apparently has not changed the range of academic ability and performance among the students, but it has changed the relative proportions of students at the various points along this range. According to Karl they still have students at the very top end of the scale but he feels to some extent "we are missing what I would consider to be your traditional B student for the college preparatory program." The change is also seen at the bottom end of the academic scale, not so much in students' ability to do the work but in the fact that a higher proportion of students do not turn in as many of the expected assignments. With the department's point grading system, in which completed assignments yield points, this failure to complete work has a significant impact on the grades students receive.

The shift in student demographics, and related work patterns in class, appears to be related to the change the department initiated in the science program: "... it is fair to say that the change in the student population was the original instigating force under considering something like this."

Decentralized science department. The school context in which this science department has been operating is highly decentralized. Both the principal in charge of the school in 1992-93, Dick Waite, and the new principal in charge in 1993-94, Carolyn Lawton, describe their role in the work of the science department as being very minimal. This hands-off approach is not limited just to the Science Department nor to curricular matters. A striking illustration of the school's decentralized approach is that the Council of Department Chairpersons decides how the school budget for supplies, equipment, textbooks, etc. will be allocated. This decision is made jointly by the chairs and is not a principal decision.

The hiring of new teachers serves as another example of the decentralized, site-based approach. According to the principal, Dick Waite:

> When we hire a teacher, the typical interview committee is the principal, or if he or she is not available another administrator, the department chairperson from the department hiring and then usually a teacher from that department as well. So two out of the three people are classroom teachers that are making the decision ... The only thing that the district does really is they screen the candidates to make sure that they are properly credentialed.

Supportive administration. The science department teachers feel the administration is very supportive of what they do. Karl describes it as "extremely supportive of the program." This support comes not just from the principal but from the vice-principal and the guidance personnel who have "to the best of their understanding been very supportive." In other words, the counselors have encouraged the students to take the Coordinated Science classes. This supportive advice from the counselors, of course, has been enhanced by the popularity of the program itself. The principal noted that the program is very popular; there has been "excellent student sign-up" for the courses.

District Context

The decentralized school situation reflects the highly decentralized nature of the district, a high school district with ten 9-12 schools and no elementary or middle schools. The Westview departmental budgetary decision-making described earlier is typical of the school district. The district does not have a science coordinator. As the principal, Dick Waite, described it:

> In this district the science department chairperson from each school meets with a district principal. And that committee really is the science expertise of this district. In this district, because we are so decentralized, it is easy for us to change. Therefore, it was very easy for Karl to implement this program because he wasn't going to fight a science bureaucracy at the district level at the same time. The district sees the value of it and they have asked Karl and some of the other people from the program to come and speak at the Principals' Council.

The freedom the district gives the schools in hiring teachers, includes freedom to hire teachers at all levels of experience. According to Dick:

> For example, when we hire people, the district doesn't put any limitations such as having to hire a first year teacher who will be at the low end of the salary schedule. In this district we can hire a teacher and give them credit for I think up to about fourteen years of prior experience. And so, when we hire a teacher it is very typical that we just go out to another school district and hire a very, very experienced teacher to come right in.

Along with its hands-off approach to decision making on curricular matters, the district has supported curricular change in the science department by allocating district moneys for some special expenses involved. According to Karl, an additional allocation of about $3,000 was made to buy particular chemistry textbooks (ChemCom) for the Coordinated Science classes when needed at the beginning of the program. He also thinks of the district as very supportive in terms of submissions for the University of California approval of their program and other such procedural matters.

While the district supports the Westview science department because its work is consistent with state expectations, district-level personnel recognize that there are differences of opinion among district science teachers about these changes. Given their hands-off approach, they move rather slowly in terms of putting district pressure on schools to make such changes. Since the department chairs of science constitute the district's science leadership, it is clear that the changes will come as the department chairs are convinced it is needed. In other words, a new vision of science teaching will not be imposed on individual schools by district policy other than as it is viewed to be necessary to meet state directives.

State Context

State influence on the science curriculum is quite pervasive and is felt by the science department in a variety of ways. In discussions about state influences, Karl referred back approximately ten years to a new state high school graduation requirement of two years of science. More recently this influence has been felt through the new California Science Curriculum Framework which, in summary, can be said to reflect many of the science reform efforts at the national level as espoused in the National Science Teachers Association's Scope Sequence and Coordination Project and the American Association for the Advancement of Science's Project 2061.

II. THE REFORM CURRICULUM IN PRACTICE

History of Coordinated Science

Although the first pilot class developed by the department was a major departure from past practice, the Coordinated Science program at Westview High School was to undergo continuing change over the next four years in terms of staffing, materials, and course organization. While this evolution has required continuing and demanding work from the teachers over the years, their commitment to the program has persisted. An important incentive for both the initial efforts and the continuing work was the conviction that the new program would reach more students and enrollments in science would be larger as a result.

First year of the program. The first year of the program consisted of one pilot test class of Coordinated Science team taught by three persons: Karl, the department chair and a biology teacher, Julie Owens, a biology teacher, and Vicki Gerhard, a chemistry teacher. It emphasized biology and chemistry more than the other sciences although all were included, and each of the three teachers was able to teach mostly in his or her particular area of expertise. This approach served well in the first year pilot test, although the logistics of the team teaching arrangement were not sustainable in the subsequent year when the number of sections of Coordinated Science expanded.

Second year of Coordinated Science. Following the pilot test year, a relatively small amount of summer work was done to prepare for large scale use of the program in the fall; a few key teachers spent about thirty clock hours each writing materials and planning. This salaried time, along with a couple of release days during the following year, were the extent of the extra time for which they were supported; additional development time "came out of their hides." At this point the science department was not only teaching an expanded number of first year coordinated science classes but developing the second year course as well. The resulting large time demands led them to restructure the arrangement part way through the year to accommodate these pressures. As Vicki expressed it:

> Originally I was going to do the second year as well and then when we initiated the second year we found that there were five of us that were doing both first and second year and it was a nightmare ... We bit off more than we could chew. So, I stayed with the first year, some of the others stayed or went ahead and concentrated on developing the second year, and I'm glad that I did that.

Such adaptations, along with an apparent high level of trust and communication among the faculty made it possible for them to move ahead successfully.

Student demand for the course in the registration process was both an encouragement to the staff and a source of difficulty and extra work. According to Karl:

> We thought we could get maybe six classes and that would be--we would be happy. Well, through a lot of different occurrences we ended up in twelve sections of kids. That is very good

> for your ego, but it is not very good for planning. You go from one to twelve and there is a whole lot of stuff you can't do with twelve that you could do with one.

With twelve classes of Coordinated Science split among years one and two, the science department had its work cut out for it. Six of the seven science teachers in the department were teaching one or more sections of Coordinated Science, generally along with some of the traditional program. The team teaching arrangements that had been used in the pilot test year were no longer possible. A large amount of coordinated planning and team meetings for the first and second year levels of the course continued, but generally teachers had individual sections of a class to themselves.

The three teachers teaching the first year course consisted of one who had participated in the pilot test year and two who were new to Coordinated Science. The first year's experience was valuable to the new teachers. As one of these new teachers, Dave Vaughn, indicated:

> They did really a nice job of writing down things that they did, and kept track of everything that they did, and we relied on that quite heavily. If we found again the logistics wouldn't work, we just didn't have the equipment to deal with all the classes - some things you can do with one class you can't do with the masses - then we started to rely on one another. Okay, well what can we do in place of that, that they will get the same concepts?

A collaborative process was in place that made use of the experience of the first year pilot test and depended upon teamwork among the teachers.

The first time offering of second year Coordinated Science was taught by the other two pilot year teachers plus one new to the Coordinated Science program. Again communication and teamwork were important to the process, although as the year progressed, circumstances led to some diminishing of the collaboration among this team of three.

During this year, some of the teachers also began to look at new forms of assessment such as embedded assessment, authentic assessment and portfolios. Although apparently not part of the initial design for the program, these approaches began to emerge as teachers came in contact with new assessment ideas; their use increased as time went on. Some of these new ideas apparently entered the program as a result of teachers' growing contact with educational personnel outside the school. They started to attend more conferences, and in some cases were scheduled to speak about what they were doing in their science program.

The emerging Coordinated Science program was a blending of the science content found in the various courses of a conventional science program. In the first two years of Coordinated Science the students were to get roughly a little over a semester of biology and a little more than a semester of chemistry, with the remaining time distributed among earth science and physics. The third year of Coordinated Science would be primarily biology and chemistry. The student taking a fourth year of science would go on to physics or advanced placement biology. There is no plan for a fourth year Coordinated Science course.

Within this new Coordinated Science program no one set of textbooks is used as the basis for the course; different texts are used for different portions of the course. For the most part, these textbooks are available only in classroom quantities, not one for each person enrolled in all sections of the course. The students use them in class with no provision for taking a textbook home.

To supplement this in-class use of textbooks, the students are provided with locally-produced activities books containing a collection of laboratory and classroom activities. Each student is provided with his or her personal copy. In addition, students have been provided with a "textette" containing more conventional text material that was written locally by Karl. This text material is focused on topics not covered well in their other textbooks. He prepared this material during released time he had as a result of a fellowship supported by external funds.

Further experience with Coordinated Science. The next year of Coordinated Science brought major changes. The third year of the program was added, with a significant enrollment of students electing to continue beyond the second year of Coordinated Science. Another striking change was a massive turnover of personnel, none of which appeared to be related to any disenchantment with teaching Coordinated Science. One teacher became a counselor at the same school, one began teaching part-time at the same school because of family considerations. Another moved to a part-time assignment at a school closer to her home for the same reasons and a fourth teacher returned to a teaching position at a school much closer to her home. Although the reasons among the four individuals were not all the same, there was no indication of disenchantment with Coordinated Science *per se* on the part of anyone. In fact, individual interviews with the teachers indicated just the opposite.

The 1993-94 school year began with Karl, the department chair, and Dave Vaughn, who had begun teaching Coordinated Science only the previous year, as the only experienced people in the program. Frank Brody, the only teacher in the department who had not yet taught Coordinated Science, took on some Coordinated Science as part of his assignment and three new full-time teachers were hired for the department, all of whom would teach at least some Coordinated Science classes.

The process of selecting the three new teachers was very explicit in identifying what the program was and what was expected of the new teachers. As Karl put it, "This is what we do here; if you are not willing to do it we are going to fire you, so tell us now." The people hired included two persons, Bill Niemeyer and Laurie Metz, who had just completed a teacher education program and one, Fran Kline, who had seven years of teaching experience in another school district.

Such a large turnover in personnel in the midst of an experimental program obviously was not a minor challenge; it was to be a major test of Coordinated Science at Westview High School. Yet, as the school year came to a close and he looked to the next school year with a staff that was expected to remain intact, Karl seemed optimistic that the program will not only be maintained but improved. Based on their previous experience, he is convinced the second time through a course is always much easier, and he expects the new teachers will be even more enthused about a program that at this point they give every indication of already being committed to. Although there is no guarantee the scheduling process will permit it, he also is looking at the possibility of returning to some of the team teaching used in their pilot test year. Although the expected scheduling problems in doing so are not simple, he expects to make another try at working with the school administration in incorporating more of it into the program.

Goals of the Program

The Coordinated Science Program at Westview High School is based on a vision the entire staff of teachers generally understands and "owns." Three propositions provide the structure for this vision as presented here: who the program is for, the intended curricular outcomes, and how achievement of these student outcomes is anticipated.

Intended students. The Coordinated Science Program is intended to be for all students. It is directed to the college bound students within the student body, the average student, and even some students who would be considered by some definitions to be special education students. The course is also said to be a "college prep" course. In other words, the course is expected to provide that science background needed by students going on to college and to provide this kind of background for all students whether or not they have college as an aspiration.

Intended curricular outcomes. The vision of the curriculum held by the Westview science teachers is one in which concepts, ideas, and big themes are taught instead of isolated facts. In describing this curricular outlook, it is common for teachers to use the word "connections." They talk about making connections between different concepts and between concepts and their application in the "real world": "I think the basic goal is for them to understand that everything is interconnected. You certainly can't separate the different disciplines of science. I think it carries over even further, that all of life is related."

In their descriptions of this approach to science teaching, reference is often made to teaching themes and to integrating the content. As Dave Vaughn put it: "I think what they see now is science as a whole ... they couldn't ever see that before. I don't think they really even thought of it that way before."

Based on visiting quite a number of other schools preparing a Coordinated Science type of program, and listening to presentations by other schools at conferences and meetings, Karl is convinced that the Westview Coordinated Science Program has moved much further in the direction of integrating the various aspects of the science curriculum than most other schools with these aspirations.

In the process of integrating and focusing upon the major unifying themes and concepts, the total number of concepts taught in the science program has been reduced from that found in the typical science course. This orientation is explicitly stated by Karl in his descriptions of the program and is reflected in documents they prepared in submitting their program for college approval by the University of California system.

The teachers also describe their program's content as being applied to the "real world," or to new situations, or to life. As Betty Cronin, one of the science teachers, described it:

> They are seeing science as it is applied in life today versus science as it applies to this textbook ... I would expect all of these kids to get through here and know a little bit more about themselves and how their body works and how their world works around them.

A central idea in her elaboration of these ideas is the concept of "connection to reality."

Another common thread in the teachers' description of what they want to accomplish goes under the label of teaching kids to think. Common phrases in their descriptions are teaching kids to "think on their own," "teach scientific processes," "to ask questions," "critical thinking," "problem solving" and "preparing students to be decision makers." Further elaboration of these ideas tends to be couched in terms of specific classroom activities--particularly laboratory activities--in which the students are asked to participate.

Another expectation is that their program will interest students in science and cause them to take additional courses in it. For many observers, student interest is the "bottom line"; the most important indicator of the success of what teachers are trying to do is that students are caught up enough in science that they want to go on further and learn even more about it.

Strategy for implementation. Most frequently mentioned in any description of how their program operates are references to lots of "hands-on work" or more "labs." It is clear they have high expectations in this regard. The California Science Curriculum Framework states that at least 40% of class time should be devoted to laboratory work. They take this standard seriously and have developed their program in a manner that includes extensive amounts of student laboratory work. Along with this description of what they are attempting to do, is language about wanting to make the program more "concrete." They want a program that addresses the big integrating ideas of science and they want the students to be able to do it in a context that is not simply abstract and theoretical. Thus, they focus on hands-on activities. Another major claim of teachers is that they spiral back to important concepts. The content is not only integrated across different fields of science and connected to "real world" situations, but the big ideas are returned to on repeated occasions.

These teacher expressions of program goals and principles are fairly broad; they are worked out in a variety of fairly specific ways. For example, they do not employ ability grouping in their program, or as some teachers express it, the program is "de-tracked." Attention also is given to what some call authentic assessment. In the minds of the teachers who emphasize this approach, authentic or performance assessment addresses the applications of knowledge and its connections to the "real world."

Another common commitment is to a substantial amount of student work in groups. Sometimes referred to by the teachers as cooperative learning, it is linked in their minds to the matter of making connections to the real world and teaching students to think. Reference often is made to having students figure things out for themselves. It is also said to be reflected in somewhat different homework assignments. These assignments are to be longer in duration and not simply answering questions at the end of a chapter in a book. The use of more writing activities in classes also is thought by some of the teachers to be a part of this process of integrating knowledge and getting students to think with it.

Key Features of the Reform

The description of goals above reflects what teachers themselves say about the program and their goals for it. A closer look at the curriculum itself, and the means of instruction used by the teachers in the actual classroom context, will provide a clearer picture of the extent to which this vision is put into practice.

Much of the description of the program will be presented in the words of the teachers themselves, since they convey their intentions as well the classroom transactions. Many days were spent in classroom observation by this researcher. Those teacher descriptions employed here were judged by the researcher to be accurate portrayals of actual classroom transactions.

The curriculum: its content and nature. When Bill Niemeyer (one of the new teachers for the 1993-94 school year) was hired, curriculum was an important consideration, according to him:

> One of the big questions in the interview was "could you teach without a text - could you develop your own curriculum?" and I said, "yea, easily."

The Coordinated Science curriculum at Westview High School can be described in writing as the faculty at Westview did in their application to the University of California for approval. But the curriculum also is reflected in the professional decisions that the teachers make on an ongoing basis as they conduct the program. Karl and other teachers made curricular decisions that are reflected in the particular laboratory activities and classroom activities selected. In addition, much of it is "in their heads." Thus, a new teacher coming in is expected to be able to adapt, be creative and develop instructional activities on an ongoing basis. The curriculum of Westview's Coordinated Science clearly is *not* a "teacher proof," or "canned program."

In spite of this variability and openness to influence by individual teachers, there is a common philosophy and conceptual framework for the Coordinated Science Program. This orientation is reflected in a number of characteristics:

Science for everyone. Coordinated Science is a course for all students, except those classified as special education students. Science is seen as important for all students, whether or not they will attend college, and Coordinated Science is expected to provide this education. All students are expected to become consumers and voters; both roles demand an understanding of science. This goal is reflected in the curriculum itself.

The Westview teachers recognize that many students will not be getting this education in college and Westview is their last opportunity to get it. Even among the many students who will attend college, only a minority will actually complete a college degree, and the percentage of Westview graduates who will actually complete a major in one of the sciences or a related field such as engineering is very small; one teacher says that statistics show this percentage to be about 2%.

College preparatory. While Coordinated Science is designed for all students, it also is said to be taught "at a college prep level." This "college prep" designation is frequently mentioned by the teachers and its seriousness is reflected in the concern for getting University of California approval for the courses. Both the content coverage and the depth with which it is pursued are intended to meet the needs of students who will be attending college.

Real life application. The word "related" comes up often in teachers' discussions of Coordinated Science. It is used in several ways, such as with reference to "students' lives," or to "the real world." Teacher Linda Voss describes it as follows:

> Giving them an idea also of how science could affect them directly. The ozone layer is probably a good example of that. I mean that is something that is very current and they have to understand a little bit of chemistry to understand it and they have to understand earth science and the atmosphere to understand it ... so I see it as putting it all together for them and seeing the relationships and then seeing -- then hopefully how it effects them directly.

This applications orientation is considered important both because of how students use what they learn in school and as a means of increasing student learning. As Julie Owens expressed it, "kids that are not your real college prep kids can still grasp the concept if there is application associated with it."

This orientation to applied science in the classroom is reflected in the comments of essentially all the teachers in the department. Bill Niemeyer, for example, says:

> I think the secret to its success is the incorporation of real life problems into the curriculum, things that the students can relate to. And doing a lot of labs, a lot of hands-on.

Or as Betty Cronin describes this orientation in comparing Coordinated Science to more traditional science classes:

> And therefore I think they kinda get turned off to science or they think it only is inside the classroom and they don't really see how it fits into the rest of their life. And I think the way we are teaching this class now, number one we are making the connections.

Relationships between the sciences. The word "related" is often used by the teachers in an additional context, namely in addressing connections between the various fields of the natural sciences. Aspects of various fields of science are taught in proximity to each other, with overt connections between them. A lab activity, for example, may look like one found in any other science class but is done in a context where its connections to other aspects of science are made very explicit. Julie, for example, in discussing a nut burning lab said:

> I think it is a good lab and it fits into doing the digestive system whether it is in Coordinated Science or biology. I think they get perhaps a little more out of it in the Coordinated Science because we've talked about the burning of petroleum and it uses, so there is a connection there that they can make, that there are many different kinds of energy sources.

This comparison of biology and Coordinated Science came up often in conversations with Julie:

> Teaching straight biology, I think you are much more limited in your explanation of any particular phenomenon and to incorporate physics and earth science as you explain other things gives a much clearer picture of why things happen, why things are the way they are. And that is what I like about it ... you can explain, that something much more fully in kind of a real world sense, that the kids are going to be able to relate to, identify with, hopefully remember.

Such conversations contain frequent references to "making connections," and "getting kids to think." Another word teachers sometimes used was "themes":

> I guess what could be different is the continuity that flows through the course. You know there is a theme that is brought up at the beginning and it is carried throughout; it is upheld within the labs and there is sort of a culmination at the end of the semester that deals with that theme, and I like that idea, and I think the kids do too.

The discussions of relationships and connections -- with reference to students' lives and to the various science disciplines -- often come together in conversations. For example, in a conversation with Julie:

> I think the basic goal is for them to understand that everything is interconnected. You certainly can't separate the different disciplines of science. I think it carries over even further that all of life is related and we do with it--the cross curriculum writing and art projects and that sort of thing--that everything that they are learning about is just part of the whole and that they come away with an appreciation for parts that they didn't appreciate before.

Vicki offered a specific example of how these ideas come together in practice in her teaching:

> When I teach the Coordinated Science class we study gas laws; in fact, we study more gas laws in Coordinated Science than we do in chemistry. And, but we touch on it first semester when it comes to scuba diving and production of soda pop and solubilities and so forth. So we study Charles' and Boyles' and Henry's Laws first semester, and, but, they are all really applied hands-on things that they can really understand. Second semester, again we just had gas laws again -- Charles' Law, Boyles' Law again -- and worked with generation of gases and so forth. And third semester they will study gas laws again in respiration, and again they will be doing some of these same laws over and over. But in each instance, it will be very concrete approach instead of just a theory. Instead of a one-shot, theoretical and mathematical approach it will be a real concrete and applied nature.

For the reader familiar with generally available U.S. science curriculum materials, the ChemCom chemistry program, the chemistry text materials used in the Coordinated Science program, may be a useful reference point. The curriculum philosophy reflected in the Westview Coordinated Science Program is highly consistent with the ChemCom orientation. Their applied orientations are strikingly similar, although because of the scope of the two programs, the interrelationships among the various sciences is more prominent in the Coordinated Science program than would be found in the ChemCom materials.

Different content organization. The content of Coordinated Science is said to be the same content that would be found in other more traditionally organized science courses, except that it is organized in a different manner. As Linda Voss expressed it:

> They will get the same concepts, but ... it is spread out over a long period of time so that it is not just all of it at once - but it is a little bit of it here and a little bit of it there and a little bit there, each time getting a little bit further along, but not all at once.

Karl, the department chair, offers a description that is very similar:

> We took stuff we were already doing and said, 'How can we put this together?' Some of it was not modified in any way; it is the same material. Some of it, in order to show some connection, has been modified slightly to get into a particular place.

When asked to describe the relative emphasis among the various fields of science within the Coordinated Science Program, Karl indicated that within the first two years:

> My guess is that they get about they get a little -- they get over a semester in biology, a little more than a semester of chemistry and then what is left over is earth/physical science and physics in the two years.

The third year of Coordinated Science has a heavy emphasis on biology and chemistry. Coordinated Science ends with the third year, although students can go on to take a fourth year of science in this four year high school. Such a course could be, for example, physics or advanced placement biology.

Connected to current events. Given the orientation of Coordinated Science as described above, it is not surprising that teachers attempt to making connections between what they are teaching and current events. Betty, for example, expected her students to bring in a science-related news article every week. They were expected to summarize it; she used their individual work as a basis for making the connections she often talked about.

Increased student interest in science. A constant theme in the teachers' discussion of Coordinated Science is the hope that their approach will generate more student interest in science, cause them to take additional courses in the field, and have a more positive attitude toward science. Their success is indicated by the enrollments in Coordinated Science at Westview High School -- enrollments that exceeded their expectations. As Betty expressed it:

> The whole idea is hopefully we are going to get more kids interested going on in science and maybe even taking a third year when they don't have to, just because it interests them.

Coordinated Science is a vehicle for gaining and maintaining student interest in science.

Topics are revisited. As indicated above, various science topics get revisited throughout the curriculum. This approach, of course, is consistent with that of the NSTA Scope Sequence and Coordination Project which was the stimulus for this new program at Westview High School. Often contrasted with the so called "layer-cake approach," ideas are built upon and revisited in an attempt to build an increasingly sophisticated understanding. Julie describes it as follows:

> You kind of dip out and then you come back to what the main idea is, or the themes, and when you go out again, then you explain something over here and you come back to the theme, and you are constantly darting off and coming back ... You always come back to your theme, or your problem, or your purpose, and it explains the situation more fully, I think, and it allows kids to see that everything is not cut and dried, or black and white.

More in-depth assignments. In their descriptions of the Coordinated Science Program teachers often make reference to student work assignments which are longer in time, involve more writing, and require more independent effort -- in contrast to what they see as being the typical assignments in other science classes. This orientation also is reflected in some of their laboratory activities.

Integration with Math and English. Although the *formal* integration of Coordinated Science with work done by teachers in the mathematics and English departments is not extensive, there is a certain amount of it and the Coordinated Science teachers are quick to note connections between what they are doing and these other subject areas. While mathematics traditionally has been associated with science and the references to it here are not at all surprising, there appear to be more connections to English than would be found in the typical science department. This connection is reflected in the writing assignments given by the science teachers.

These relationships were noted in interviews with both the mathematics and English department chairpersons. Both chairs were well aware that the work being done in the science department involved such connections. Both were most positive about it and expressed their approval of this emphasis. The principal, Dick Waite, also was aware of these connections and felt that, to a small degree at least, the work of the science department was influencing what was taking place in the rest of the school. He also was hoping that as their school entered into the state accreditation process, there would be more interaction along these lines and the influence of the science department would spread.

Continual change. A final characteristic of the curriculum is continuing change, in terms of what is taught and how it is taught; faculty members expect curricular and instructional practices to change over time. Karl indicated that he thinks "the content will constantly be modified."

Teaching and learning at Westview High School. To discuss teaching and learning at Westview High School one must address both the content of the curriculum and the manner in which teaching and learning occurs in the classroom. Having addressed curricular matters, we now attend to the process of teaching and learning.

To understand the nature of the Coordinated Science Program, it is helpful to take into account both the actual instructional activities as observed in the classroom and teachers' explanations of what they were doing, the goals they hoped to accomplish, and their rational for actions. Some of these teacher explanations are a good place to begin.

Extensive laboratory work. In any discussion of coordinated science, teachers mention that they do a lot of "labs" or "hands-on" activities. This description of student laboratory work generally is accompanied by some statement of conviction about its importance or the value that it has for students:

> ... we have a lot of hands-on, doing labs, finding it out for themselves, and for one that is where most students interests come in science ... so one thing that I really like about the class is that there is a lot of labs, a lot hands-on, a lot of their getting to it rather than my lecturing.

The teachers are convinced that the students like the labs and that it is one of the reasons that Coordinated Science is popular and has large enrollments. My discussions with students bear out this judgement. When I would ask students what they liked most about Coordinated Science the vast majority indicated they liked it because they did "lots of labs."

When discussing the nature of these laboratory activities, teachers often would indicate they were more current or applied than many labs found elsewhere, or that they made connections with real life. Other descriptions highlighted the extended nature of some laboratory activities --over several class periods -- and the variety of activities in which students could be engaged while doing laboratory work:

> We did a lab, a series of labs, which lasted a few days, on this toxin in the water, and the students had to figure where ... possible could be coming from, and they had to test different wells, and we talked a little about geology and soils, and so they used chemistry and geology and some of their own thinking to figure out what well to test next and sort of figure out where the poison was coming from.

Along with teachers' explanation that they do lots of labs there is usually a reference to doing "very little lecture." Late in the school year Karl indicated:

> but in terms of full period lectures, I doubt if September -- I really doubt that there have more than 6 to 8 days where we have done full period new material presentation. Frequently there are two activities, maybe one of them some kind of a lecture material, the other one would be some kind of cooperative thing, and so that we try to have a side view. I mean we are not here to beat them to death

> with material and I personally think worksheets are just about useless and so we don't do a lot of worksheets.

Dave used somewhat similar language in describing this lack of lecture and the alternative focus to Coordinated Science:

> With Coordinated Science I think a lot of that is -- here it is very little lecture. Let them come up with the answers, let them be involved. There is more group work with them than there is in a normal science class. So they are helping one another.

As already indicated, worksheets are not a prominent part of the course either, but what is meant by worksheets in this context is relevant. The sort of worksheets being avoided are those which have fairly detailed questions that can be answered by looking up material in a textbook.

The replacement for extensive lectures and worksheets is more laboratory work and what is often referred to as group work. An indication that this group work is different from what students commonly encounter in most other classes, is teachers' awareness that it takes considerable time for the students to do work in this manner. Over the course of the year students learn to work effectively in groups.

In describing such student work, teachers talk about doing it in a more concrete fashion that involves more writing, drawing, and other forms of participation. There is a desire to start with the concrete and then move to the abstract:

> I could start out concrete, and then depending as to what I judge is happening in the move -- but I think I would more start out there and then make the move to the abstract ... I do a lot more writing, more conceptual basis and having students, by writing, by drawing whatever, tell me what they know rather than just crank out a balanced equation or a physics answer.

There is frequent reference to "show me what you can do," and references to "making connections." This way of teaching is said to be used to get students to think more, or to engage in critical thinking. Although it is not an approach that all teachers in Coordinated Science use--some don't even recognize the term--concept mapping is a technique a few teachers used in limited instances, even though it was not a stated part of the Coordinated Science program.

Classroom observations. Having presented teacher descriptions of the teaching and learning in their classrooms, consideration is given to what was actually observed in the classes. As noted earlier, teachers claim laboratory work to be a large part of the courses, fully 40% as suggested in the state curriculum guidelines. Every indication from random visits to classes was that laboratory work actually did constitute at least this much of students' time in class.

When doing laboratory work students largely were on task and actively engaged in the intended activities. In a large percentage of cases students seemed to be working with minimal teacher direction and quickly were on task when laboratory work began in a class. This situation usually was the result of well developed classroom management skills, particularly on the part of the more experienced teachers. Printed laboratory directions for students were concise, efficient, and well organized. Teachers such as Karl and Frank very carefully orchestrated the beginning of a laboratory activity to get students quickly involved in the task.

In one laboratory session, for example, Karl announced immediately upon the ringing of the bell that he expected the students to be in nine groups within one minute. Each group was to have not less than three and no more then four people. He identified the exact spot in the room where each of the nine groups should be and told them as soon as they were in these groups he would give them additional instructions. It was obvious that without further instruction the students knew what was expected of them and they soon were ready to go.

It was clear that they had been "trained" to work efficiently. He then distributed instructions which they were to read. After doing so, they were to acquire a sheet of paper and put on it the name of every person in their group along with the job that each person would be doing. He left it entirely up to them to take the initiative in carrying this out without any more explanation. After some time to read the instruction sheet and get this information down on paper, he announced that when someone from a group brought him this sheet of paper, he would give them the materials needed. In a relatively short period of time the students were fully engaged in the task a hand.

Since the particular laboratory activities, including the equipment and written instructions, generally were the same for all classes of a given level of Coordinated Science, student activities appeared quite similar from one teacher to another for a given activity. Although all teachers were not as efficient as Karl and Frank in managing such activities, student work did not vary much.

The laboratory example given above illustrates not only the organizational approach but the fact that work is done largely in groups. In addition, the laboratory activities are characterized by a high level of student involvement, and a variety of activities that may or may not require sophisticated science equipment. One activity on speed and motion, for example, required each of the classes of students to spend the class period out on the athletic field with stop watches timing various events and taking other measurements. A related activity conducted in the classroom used a large number of dominoes in student groups.

In addition to the substantial amount of time spent on laboratory activities, significant time also was spent in class work that involved student discussion and teacher presentations. It was quite varied from one time to the next. Although there certainly were variations from teacher to teacher doing the same activity, these variations were not as large as those found within a given teachers' classes from one day to the next.

Although the amount of time devoted to it was limited, information at times was presented orally by a teacher, often assisted by material displayed with an overhead projector. Such presentations typically were interspersed with considerable discussion and questioning that was largely teacher directed. Much of this discussion, however, was related to what teachers so often referred to in our interviews as "connections." Betty talked about these discussions making science interesting and related to life:

> I love this--in the news articles that we are having them bring in--they bring in an article each week and they have to summarize it and it has to be a science article and that is another thing that I think makes them aware of how much science is around them.

While there were many instances of such connections in the class, there were other instances in which the presentation was more abstracted and condensed. For example, in one of his classes Dave made a presentation of Newton's Laws within a period of fifteen minutes. While there was some dialogue with students, it was by and large a presentation to which students listened. Subsequent discussion with Dave indicated that even though he thought the students may have heard some of these ideas prior to high school, this presentation was their first systematic introduction to Newton's Laws in the high school science program.

Cooperative groups. It is evident from the descriptions of teaching and learning given above that cooperative groups are a prominent part of Coordinated Science instruction. This characterization is particularly true of the original set of coordinated science teachers in the program in the 1992-93 school year. It was present in all of the Coordinated Science classes and three teachers in particular tended to talk about its value with conviction: Betty, Julie, and Vicki. They were utilizing this approach not simply because it was a part of the Coordinated Science Program but because they were convinced of its importance and value in their classrooms.

Class observations also show that students had learned to work in groups effectively and did it with comfort and ease. Teachers made reference to the fact that students had learned how to work in groups, even though they may not have been particularly skilled at it prior to coming into a Coordinated Science class. These skills which enabled them to work effectively in groups were varied and even included simple social skills.

While students may display some initial awkwardness in group work, they gradually acquire understandings which enable them to do it with ease. They not only acquire the needed skills but accept work of this nature as a routine part of their Coordinated Science classes. As Julie indicated:

> You know after a while they are - you can just say, well we are going to do this and the kids know what the routine is and after they get into the second year of Coordinated Science they are really quite well trained.

Julie goes on in this discussion--which took place the following year at a new school where she is not working with Coordinated Science--to indicate:

> and to come back over here and see that they don't know how to work in groups very well, but they don't have the social skills that they learned--in like at Westview--but I can't give them an activity and say okay let's do this because they have never done anything like it before.

Vicki's description of the ease with which students are able to work in groups is as follows:

> After they have been in the program for a year -- by the time they go to the second year -- they are so malleable it is absolutely unbelievable -- groups, I mean they are willing to get into a group, they are willing to do fifty different activities per hour. They don't question, they just "oh good, we are going to get to do some new experience, all right!" you know and they don't question doing creative writing things, they don't question a lot of things that I think that they would have otherwise. Because they have done so many different things they just, its just one more of the many things we got them to do.

The teachers have a variety of reasons for doing a lot of work in groups, not the least of which is that the students like doing it. But mainly they employ this approach widely because they are convinced it makes it possible to reach more students and get them actively engaged in learning, or as Betty put it "it makes it easier to get to all the kids."

The dynamics of group work. It was apparent in observing classes that for many teachers this cooperative approach to learning had become second nature and was reflected in general interactions in the class, whether or not students intentionally had been put into groups. In one of Fran Kline's classes, (a new teacher beginning her first year at Westview in 1993-94), for example, students were engaged in productive work that involved consultation with each other in a productive manner when they needed it. In spite of Fran's designation of an upcoming fifteen minute portion of the class as one in which they were to be working individually on some chemistry problems, the students seemed to naturally cooperate with each other, with one person explaining to another how something was to be done when someone needed assistance. They helped each other as needed seemingly as a matter of course. The classroom atmosphere was relaxed with a fair amount of quiet conversing among students, but it was in the context of students' active engagement with the work at hand in a productive manner.

Working in groups appeared to be accepted by all of the Coordinated Science teachers with little hesitation, although Frank would point out that it didn't solve the problems related to the many poor students who were part of his classes. Group work is truly accepted and widely used throughout the Coordinated Science Program.

The only context in which cooperative groups were questioned was when the discussion involved parents or grades. Although discussions with teachers and administrators indicated it was not at all a big issue among parents, an occasional parent was concerned about group work and teachers were sensitive to this sentiment. Concerned parents generally were ones who perceived their child to be very talented and wanted their high achieving student to be challenged to achieve at a high level. Thus, the discussion of cooperative groups for these parents would naturally connect to grading practices and "detracking," not grouping students according to ability level. Julie made reference to a meeting of parents she attended as a result of her own child being in a gifted and talented program. As she put it:

> Some of the parents there were furious that their children were put into groups because they felt that their higher achieving child was always being dragged down by the people who didn't get their share or couldn't understand anything at all and I felt that it was a real snobbish attitude to

> take, that it was more important to learn some tolerance and ways of working with people, a lot of those parents practically said "well tolerance be damned, I want the child to get the best all of the time." So I play down the role of group work and one way of doing it is in grading--don't get too specific, don't upset the high achievers too much and they will have ample time to do their individual work as well as they want to.

Other teaching arrangements. The specific within-class teaching approaches described above took place within the context of a variety of different arrangements over the life of the Coordinated Science Program. When the program began they had a fair amount of team teaching. Karl described the overall approach as being "as close to team teaching as we could do it." During the life of Coordinated Science at Westview High School, however, the team teaching aspects largely disappeared as a result of logistical constraints.

During the 1993-94 school year they returned to team teaching in a limited way. The idea of team teaching had not lost favor with them; it was simply a matter of working out the logistical details. During this year they put three classes together one day each week for a large group presentation in an auditorium style room. They also did some trading of classes that meet at the same hour to enable teachers to teach their areas of greatest expertise to both classes.

Their goal for the next year is to get block scheduling. This goal appears to be high on Karl's list and he is working within the school to achieve this end. He also is attempting to get common planning periods for Coordinated Science teachers so they have even more opportunity to plan together and teach together.

Additional matters that stand out in any look at the classrooms are that (1) the program is not based on a single textbook, (2) textbooks do not play the usual dominating role in the classes, and (3) there is an attempt to use a fair amount of authentic assessment. Each of these topics is worthy of considerable attention and will be addressed in a later section.

Teacher reaction to the new instructional arrangements are largely positive although there are some reservations as well. Teachers who had been in the program since its beginning, such as Vicki and Julie, are convinced that their approach to teaching has changed greatly as a result of being a part of the Coordinated Science Program and that there is no way that they will ever return to their earlier way of teaching, even if placed in a conventional setting in some other school. This judgement was reinforced in conversations with Julie during the 1993-94 school year after she had in fact made such a transition and was teaching in a different school. Her judgement was just as firm; her teaching was different even now in a new school in a conventional setting.

The main reservation about the new approaches have to do with time, both the time of students in class and the time of teachers outside of class. In discussing the time required, Betty says "it just flat out takes more time." The conviction that goes with this judgement, however, is that in spite of the greater time taken to cover material, it is worth it because of the greater learning that occurs.

The time demands on the teachers relate to trying new and varied approaches and working together with other teachers to come up with these ideas. As Fran (in her first year teaching at Westview in 1993-94), put it:

> coming up with hands-on things I think are for me ... it has been the hardest--our coming up with ideas rather than saying here is a book I prefer. I think that is probably one of the hardest things for me ... especially you know coming out of college where they said, "here is the book," and then making that transition I think has been the toughest.

General impressions. Based on many days observing Coordinated Science classes, here are a number of observer impressions. One impression is that the more experienced teachers have an easier time with the new approaches. All of them had to learn new approaches which may not have come naturally to them and those teachers who have been there longer have had the time to make that transition. Another impression of the Westview science department--one that distinguishes it from most schools one would visit--is that the teachers know what each other are doing in their classes. A third impression is limited variation from one class to another in terms of what is being studied at a given time and how it is being approached, probably due to the considerable degree of collaboration, the movement in and out of each others' rooms, and the attempt to do a joint program. These similarities exist even though the teachers have their own ways of relating to students and working with them.

Assessment

Conversations between teachers and students in the science classrooms of Westview High School fairly often include, in some manner, reference to grades, testing and assessment. The common currency here for talking about such matters seems to be something called "points." Points are earned for completing a variety of assignments, and performing at certain levels on various forms of tests and other assessments. To understand the whole picture, however, one must look beyond this sort of language--a language that is common to many schools--and look additionally at what are called performance assessments and portfolios. While both enter the picture at various points, portfolios are the most pervasive.

The use of portfolio assessment has been heaviest in the first year of Coordinated Science. During the 1992-93 school year, portfolios were used consistently throughout all of the first year classes, but its use in the second year of Coordinated Science essentially was limited to the classes of one of the three teachers. The use of portfolios in second year Coordinated Science apparently was about to expand as the next academic year began, but the large turnover of personnel which took place between 1992-93 and 1993-94 changed the picture. Expanded use of portfolio assessment did occur as anticipated--with Karl taking the lead--but the new teachers had little familiarity with portfolio assessment and it was not one of the dimensions of their work that got first priority in the midst of everything else they had to learn.

If one looks at the origins of portfolio assessment--as well as performance assessment--it appears that they did not enter the Coordinated Science Program because they were viewed as an integral part of Coordinated Science. Rather, the new forms of assessment apparently were adopted as a result of a simultaneous but separate influence. The school district was encouraging progressive means of assessment and two of the teachers, Vicki and Betty, had a particular interest in such work. As a result, these new forms of assessment entered the science program at Westview High School simultaneously with Coordinated Science more as historical accident than because they were intimately related to each other.

Teacher interest in portfolio assessment and performance assessment varies considerably. Some do not see it to be of any great consequence and others, such as Vicki, are convinced it is of great significance:

> I believe so firmly in authentic assessment, and the more I did work with portfolios and other forms of authentic assessment and alternative assessments, the better I liked it and the more sold I became.

For others, such as Karl, it was a matter of priorities. His major concern has been putting the overall Coordinated Science Program in place, and this overall effort took precedence over any one aspect of the program that may or may not be seen as a core feature:

> I think there is an advantage in doing portfolios, but ... I am not willing to buy into any of those things as the sole method of performance ... I would rather use it as a tool, it does encourage kids to do some of their better work ... I'm comfortable with where portfolios are--I don't know again that I would want to do a whole lot more with it simply because it would be taking away from some of the other stuff and that is why I am not ready to do that.

Similarly, Frank has not been convinced that it was worth a large investment of time:

> Assessment is important, evaluation is important, but once again, how much, you know if you put in a thousand hours in improving assessment, and you only improve it one half of one per cent, maybe there was a better way to spend your thousand hours.

To see where portfolio assessment fits into the picture at Westview High School, one must also look at its connection to the Golden State Examination sponsored by the state of California and a new process of school science assessment the department has been exploring. Apparently the past year was the first time that the Golden State Exam included a portfolio component. According to Vicki, it had been highly successful because there was a strong correlation between performance on this portion of the Golden State Exam, students' general portfolio work and students' grades.

Attention to portfolios also was stimulated by a school science assessment process sponsored by a league of schools in which Westview High School had become involved. The Science Department began identifying the particular outcomes they wished their students to display by the time they finished their science courses, *regardless* of whether or not they were in Coordinated Science or the regular science program. They developed a listing of these outcomes that were somewhat tied to years of the school program (whether Coordinated Science or regular science). This activity influenced how they looked at the use of portfolios and the kind of opportunities for learning they built into their instruction.

Using portfolios. The manner of using portfolios in first year Coordinated Science during the 1992-93 school year typifies their use and the role teachers seem to have for them. Each student had a folder in a hanging file box along with the folders of other students in his or her class. The students placed materials in their folder on a periodic basis; they removed older, less polished materials and retained their better products. By the end of the year they are expected to have examples of their best work in various categories, including a lab activity, a cooperative group activity, a mathematics example and a writing example. Periodically time was allowed in class for them to go over their folders and upgrade them.

The materials they placed in their folder were already graded; it was common to have a grade slip from a teacher stapled to a work example. Some of these grade slips were the result of students exchanging their papers in class for peer evaluations, while others were the result of teacher grading of their work. The expectation of the students was that their folder would be passed on the second year science class and follow them through all of the science classes they would be taking during their entire time at Westview High School.

Each item in the portfolio was expected to have a cover sheet attached to it. It had a place for the student to classify it as to the kind of work it represented, give their own self evaluation of it, and indicate why it was in their portfolio.

The specific categories of work students were expected to have in their portfolio vary from one year to the next. This variation is connected to the overall school science performance assessment being developed with the league of other schools:

> At the end of the first year we want the students to have evidence showing that they are proficient in these six things, so that means that they are going to have to have work that demonstrates that proficiency in their portfolio, and then they will take that portfolio to their second year, and then sometime during the second year they will add to their portfolio the next eight things that show that they are proficient in this area, and then go on to the third year.

Grades are of considerable consequence to the students. They receive points in the grading system for each item that is graded and put in the portfolio. At the end of the term, the overall quality of the portfolio potentially can add more points. A student's grade for the course is determined by the accumulation of points for such work, as well as points for various assignments and formal tests.

The role and value of portfolios is connected to students, but proponents of their use, such as Vicki, point out that they also are a means of gaining (1) some degree of continuity in the science program and (2) consensus about what they should be saying to parents and the public concerning their students' learning. The potential role of the portfolios in communicating with parents is indicated by an approach that Betty used:

> I had the kids do portfolios and I was so impressed with what they did that I made up a parent portfolio evaluation sheet that the kids get points for if they make their parents fill it out. And the questions asked are, "what piece of work was most interesting ...?, what piece of work stands

> out most in your mind?, what is a positive comment you want to make to your student about the portfolio?, and what did you learn about your student? I am getting back real positive things from parents ...

An indication of how far portfolios had come by the later part of the 1993-94 school year was the boxes of hanging folders stored in Karl's second year Coordinated Science class. Each student had a hanging folder and each item in a portfolio had a standard cover page with information on front and back that the student filled out indicating the category of work, a self evaluation, a summary of its contents, and responses to a series of questions for the student having to do with why he or she chose the activity, what they liked least and most about it, and what they would do differently if they were to do it again. Some of the work in the folders was revised as a result of the process through which they had taken their work in the class.

An example is a revised writing assignment by one of the students who wrote a paper on adoption of children. The assignment was do a paper on a topic which was "touchy." In addition to the rough draft of the paper and the paper itself, there was another sheet (stapled together with a cover sheet) on which a fellow student had written a critique. This standard form for critiquing someone else's writing includes a place for the names of both students, the topic, and questions such as "What was the author's position and was the position clearly stated? Do you agree with the author's position and argument? If so, why? If not, why not? Give either one additional argument supporting the author's position, or give one rebuttal to one of the arguments in the paper. How many references were in the paper, and was each source referenced?"

Overall approach to assessment and grading. In addition to the portfolios, assessment in the Coordinated Science classes includes a wide variety of other activities. In fact, the portfolios were not the most prominent part of the overall assessment. Periodically students would take conventional tests in their class, much as in any other science class. Common tests generally were used across all sections of a given year of Coordinated Science.

In addition, there was some use of performance tests. An example is described by Julie:

> They have to perform a task. They have to demonstrate a skill as part of the test and, in fact, the final for this semester has a lot of performance tasks on it. In some ways it is very conventional, because there are multiple choice questions, but it is unconventional in the sense that we post them at something like thirty four stations -- they have two minutes at each station -- so they are on their feet for the final and they are carrying their paper with them and they go to one station, maybe three multiple choice questions, another station is to - I think they have to compile a data table and do a graph very quickly - another one is they have to do a serial dilution and then determine the pH.

As indicated earlier, points are the currency for putting everything together. Betty gives an indication of the relative emphasis of the various activities in assigning grades:

> Points, everything is worth points. Tests and quizzes, somewhere thirty and forty percent of the total. Things they do in class, worksheets or little activities, labs that they start in class and finish

at home, things that they do totally outside of the class, all of these activities make up the rest of the points ... [Portfolios are] about ten percent of their total grade.

III. THE CONTEXT OF CHANGE

Many factors influence a significant reform of the type that took place at Westview High School. The analysis of this particular case highlights four such factors: (1) the vision and support emanating from national and state reform endeavors, (2) the leadership of a capable and committed science department chair, (3) the productive collaboration among the teachers making up the science department faculty, and (4) the enthusiastic, though largely hands-off, support of the local school and district administration. The following sections address these four factors and the manner in which they interacted to produce many systemic characteristics.

National and State Influences

While Westview people (i.e. teachers and principals) talk about state influences and actions effecting their work with little mention of the national activities, it is clear that national efforts in science education reform are very important factors behind the state activities in California. In fact, there is little likelihood that the state reform efforts would be going as rapidly in the current direction without these national recommendations to give them sanction. Many of these state and national level reform efforts clearly were taking place simultaneously, in a manner that shows a lot of interconnections with no simple linkage of one effort to another in a cause and effect manner. Some of the same people who were influential in shaping the state reform efforts also had some role in national reform efforts; such interconnections appear commonplace. Observers of state level activities, such as Karl, the science department chair, see the influence of Project 2061 and the SS&C Project on state developments. Without the national endeavors, the state process would not have emerged as it did.

National funding, in the form of National Science Foundation (NSF) money to support regional Scope, Sequence & Coordination activities, also was important. Some observers are of the persuasion that without this money the changes suggested by the California Science Curriculum Framework would have gotten no more than lip service in many schools.

State curriculum framework. The State curriculum framework is almost universally perceived by Westview personnel as *the* definition of science education reform in California. It is on the lips of everyone who enters into any discussion of science education change. Although some persons, such as Carolyn Lawton, the current principal of Westview, are careful to point out that it is not a mandate and is only suggested, it clearly is given more status than simply that of suggestion. It not only is the State suggestion of what science education should become in schools; it is also the basis for other State actions, which compounds its influence.

State testing program. People connected with testing programs, such as the director of testing for the school district in which Westview High School is located, are quick to point out the connection between the California Science Curriculum Framework and the mandated state test program. The perception is that the state testing program will be the means by which the suggestions in the Curriculum Framework are enforced. The results of the state testing program are published and are widely viewed as having a great deal of influence. The extent of this influence varies by grade level and subjects taught. The pressure is considerably greater, obviously, for an elementary school teacher in whose community test results are printed in the local paper by grade level and school, while the teacher of an elective high school course for which there is no test has little concern. Overall, there is little doubt but what the state testing program exerts considerable influence.

School accreditation process. Other people tend to associate the California Science Curriculum Framework more with another means of state influence, namely the school accreditation process. This association appears to be the main one made by Karl. He points out that for schools now entering into the accreditation process, the new Curriculum Framework is the definition of what a good science program should be. He refers to school programs getting "dings" if they do not do what the state document espouses, namely exposing students to concepts in *all* the science areas, something that will not happen in a traditional biology, chemistry, etc. sequence. All students simply will not be exposed to *all* of the traditional areas of science in such a program.

SS&C regional project. The Westview High School science teachers clearly see the regional SS&C project as an important resource for them. It adds further credibility to the suggestions of the California Curriculum Framework, it provides resources to initiate some local school activities that otherwise would not be possible, and it provides a context for discussions important to the teachers. The amount of money provided to the schools (NSF money being spent through the regional organization) is relatively small, somewhere in the neighborhood of two to four thousand dollars for a given school in one year. While the amount is not large, it can have an important influence in a given local situation. A department chair such as Karl recognizes this influence:

> It is going to buy me for the summer, uh, four teachers at $500 a piece to do curriculum work that wouldn't, I mean, that would have to have been done anyway, but now they feel like -- first of all they feel obligated because they are getting money, but secondly it's, -- this is important enough that they are going to pay you to do it and I think that in this business a very important factor -- everybody says how important education is, and it is not often that they put money behind it.

Teachers also see the benefit of the regional SS&C activities in terms of interactions provided for them with other teachers from other schools. There are meetings where

> ... people have been able to get together to talk, to get ideas and maybe even to find out that some of the things that you are doing aren't totally off the wall. I mean, when you are developing something new you don't know quite where you stand on the spectrum of things, and I think that's a real important part of the program, is the networking.

Money available through such activities also has the potential of increasing the interaction of local science teachers with nearby university personnel having expertise to offer to their work.

Broader state reform efforts. Educational reform efforts in this state have not been limited to subject area curriculum frameworks, such as in science. More recently, a broader State document addressing school-wide educational reform, Second to None, has gotten much attention in the school district, particularly from administrators. This glossy publication references a lot of national educational reform endeavors and is consistent with them.

School personnel (teachers and administrators) also see a high degree of consistency between the California Science Curriculum Framework and the Second to None document. Opinions were expressed indicating that the science curriculum reform at Westview would help foster school-wide reform, and in addition, the State's school-wide reform endeavor is expected to enhance Westview's new science program. Administrators have picked up on Second to None as an important document to which they must attend; they see it as a useful basis for discussions with teachers about desired changes in educational programs. The current Westview principal, Carolyn Lawton, expects it to provide a basis for important and sound reforms, and changes in professional roles, in a bottom-up manner. She intends to encourage teachers in her school to be part of a process of determining what direction they should go and what specific goals should be pursued in the school.

Difficulties with the state role. Although the description provided above of the state role in promoting science education reform has a decidedly positive cast to it, the topic cannot be left without acknowledging state-level activities which are perceived as detrimental to Coordinated Science. In particular, there was great concern at Westview High School over the question of whether or not the Coordinated Science Program would receive approval for college admission purposes from the University of California system. A big part of the difficulty is that the process takes so long. Three years into the Coordinated Science Program at Westview (1992-93), then principal Dick Waite, was expressing this concern. He indicated it was his only concern about the Coordinated Science Program, but it was also a big concern. If at that point the program did not get approval, it was a matter of most serious consequences. A district level administrator expressed this concern as well:

> And that is probably one of the biggest battles we have to fight, is trying to negotiate with the University as to how change can take place, because we can't do a pilot project with students, unless we know that four years later that these courses will be eligible.

Although Westview finally got the desired approval, it is clear that it was at least a matter of considerable distraction, and one can speculate that in some other schools this hurdle may have posed even greater difficulties.

A second matter of concern growing out of state actions is the process of teacher certification. In fact, interviews with Karl would lead one to the impression that this was a matter of even greater concern to him than the University approval problem. At the end of the 1992-93 school year he was facing the prospect of two of the science department teachers not being eligible to teach in the Coordinated Science Program. A letter had been received from an auditing office which is an arm of the State Department of Education, indicating that they had these difficulties. Essentially, a teacher of Coordinated Science would be expected to have formal certification in *all* areas of science. The matter was finally resolved, but only with considerable difficulty and a feeling on the part of Karl that this might be "the last straw." As in the case of University approval, timing was a part of the problem: "Here we get this three years down the line."

An accommodation was finely made by the state commission handling teacher credentialing. Apparently, the latest edict -- as of the 1993-94 school year -- was that to teach the first year of Coordinated Science one just needed a valid science credential, and to teach second year science a teacher had to be credentialed in a minimum of two science areas. The only way around it was perceived to be through some form of team teaching. In the case of Westview, this latest ruling seemed to solve their problem when taken together with the fact that they were hiring several new teachers, carefully selected in accordance with these credentialing expectations.

Leadership within Westview

The educational reform environment fostered by state level activities is crucial to what has taken place at Westview High School, but the true driving force in this particular case is Karl Tozer, the department chair. Without him, what has happened at Westview would not have happened. If one is inclined to attribute the change largely to the State influences, one then must also ask why the reforms occurred here and not at other schools. There is a unanimous judgement at all levels--science department, school and district levels--that Karl is the underlying reason for the existence of the program.

One of the teachers says, "Well, the driving force is certainly Karl, if he were not so totally committed to it as the director, and all of that, it might have fallen through." A district administrator said, " Karl is where it got started." and a second district administrator said, "I think Karl has been the driving force, that's--you know that seems very clear." When asked what was behind the new program at Westview, another teacher said, "Oh, I imagine that most of it was Karl, you know being persistent and having a vision and doing so much of the work himself that he went in prepared enough that he is able to get the change implemented."

Having said that Karl has been so influential in making the change take place in his role as department chair, one is still left with a question as to what makes him so effective. Neither face to face interactions with him, nor observations of meetings he leads, nor the comments of other people in interviews conveys an image of the stereotypical charismatic leader, although the word "enthusiastic" has been used by his colleagues. A substantial number of important characteristics are perceived to be important to his success; none would be particularly surprising to someone familiar with the research literature on leadership, but it is of interest to examine what has made this particular individual successful in this specific situation. Although the site-based orientation of his context creates a situation where he did not have to fight a local or district bureaucracy to make changes, none the less, the success of the Westview program comes back to his personal leadership.

Vision. As with all effective leaders, Karl has a vision of what he wants to have happen. Not only has he had a vision of what Coordinated Science could become at Westview, he has been able to communicate it to others and to translate it into action.

Knowledge. His vision has a foundation in knowledge. As indicated by the previous principal of Westview, Dick Waite:

> He is very knowledgeable, he is very involved at the state level, and so he has a wealth of knowledge that I would say maybe other department chair persons in his position would not have ... he knows what is happening, he is aware of it, he is on the cutting edge of really implementing it.

One of his fellow teachers describes him as analytical and someone who is always figuring out what to do. Furthermore, he understands his role and the influence he is having in this role as department chair. He understands that he is a catalyst and the program development would not occur if he were not doing what he is doing.

Supportive. Karl is perceived by the teachers in his department as supportive, not only in a personal sense but in terms of getting the resources that people need. On some occasions, the resources are relatively minor, but he is quick to recognize when they are needed and obtain the resources important for the teachers. They understand that he plays this role and attach importance to it.

Persistence. Another important characteristic is persistence and consistent follow through. Throughout the period of time in which the University of California approval was being sought, for example, he took the necessary bureaucratic steps and kept providing assurance to the various people involved--both teachers and his principal--that the approval ultimately would come through. Both the teachers in his department and fellow department chairs within the school see him as a focused and strong willed person who follows through. A fellow department chair described him as "... the expert at this, he is a very strong willed man; he is a very pleasant man; he has got a balance of being gentle as well so he--I feel safe with Karl."

These characteristics are related to the fact that he is perceived as being a dedicated educator with superb organizational skills who gets things done. In addition, he does a lot of the work himself and the teachers within his department see this and understand that he is doing his share of the individual work, such as preparation of materials.

Personal skills. He has the interpersonal skills required of a leader. The teachers in his department see him as someone who gets people to work together and as someone who builds up other people. Even district level administrators recognize that he shares the leadership for various activities among the teachers in his department, such as activities that involve teachers at the district level. Teachers within his department see his style as being very participatory and one of the new beginning teachers in the department volunteered that he was her mentor.

Respect. A word used to describe Karl by fellow department chairs and the principal is the word "respect." He is respected by his colleagues for who he is as a person, teacher and leader. He is seen as an educator with high standards who is able to achieve what he sets out to do.

Teacher Collaboration

Leadership is essential to establishing a process of teacher collaboration, but it is through the teacher collaboration itself that much of the important reform work occurs at Westview. This process creates communication among teachers in the context of their collaboration on developing materials and making plans for their classes. Fundamentally, it may be the most powerful force for change within the science department.

Outsiders to the department (i.e., the principal, other department chairs, and district leaders) tend to emphasize Karl's leadership when talking about the origins of the science education reform in the Westview science department. Insiders to the department (i.e., the teachers) tend to emphasize communication and collaboration with their peers as the basis for what they were doing. As Dave put it when asked how important collaboration was to what was happening within their department:

> Paramount. I mean it has got to be the most important thing that we do, we all work together on it, we all have input on it, we're all communicating almost on a daily basis.

The Westview Coordinated Science program was not developed on the outside and brought into the department. It was developed from within by the collaborative actions of the faculty.

Characteristics of collaboration. The context in which this communication and collaboration has occurred is in the development and planning of the course materials and instructional activities. Meetings are not held simply for the purpose of communicating information; they are held to accomplish specific work that needs to be done. At the same time, the teachers themselves recognize that the key to getting this work done is communication. The climate in which this communication takes place, of course, is not the norm in most school settings. The culture of schools is one in which teachers tend to work in isolation. Many of the teachers in this particular science department are pleased at what they are gaining from this atypical arrangement.

One of the collaboration outcomes is that the teachers depend upon each other's expertise. "And so we are complementing one another; we are - we have our strengths and we have our weaknesses and that is the whole concept of the program."

As a result, a great deal of learning from each other occurs among the teachers. This learning pertains to subject matter a given teacher may not know, new instructional strategies and aspects of the curriculum that could be changed.

> "They (students) are asking me some questions that maybe I don't know the answer to, but I am going to say hold that thought, and be able to go and check and find out and bring their wealth of information in and say, 'Hey this is what it is!', and I like that."

Teachers also make reference to getting together with their peers and brainstorming the best teaching ideas, talking them through, and figuring how they can put them into practice in their classes. In this context, mentoring of inexperienced teachers by the more experienced teachers is a routine and normal activity. The teachers who are not so creative benefit from the innovative ideas of the more creative teachers. Teachers are very aware that they have acquired a larger pool of ideas as a result of this sharing.

In addition to this very specific sharing of knowledge and insights, there is a motivational factor as well. The teachers talk about *liking* to get together to discuss such ideas and being *excited* about what they gain from it. Another word that is used in describing the benefits of this collaboration is "support."

> "I get a lot of support from the other teachers."
>
> "I ... there is a difference between night and day, I mean in the old days, I mean 'Hey, you are on your own.'"
>
> "You know, there are sometimes when it is really nice to have somebody you can go to and just vent a little bit and not have them fall apart on you."
>
> "The support has been great."

In addition to knowledge gained--and the more affective dimensions of this collaboration--teachers in the science department talk very specifically about sharing the work among themselves. They talk about one person running off materials, another one redoing tests and yet another one ordering films. Within one planning team, a task such as the ordering of films goes to one person on a regular basis, while another teacher does the calendar for their classes on her computer. There is a feeling that everybody carries their own weight and does their fair share. They feel that together they can accomplish something that no one of them could do alone.

The Coordinated Science Program involves different teaching approaches than in the traditional program. Such changes in the role that teachers play are not easy to make. Observers often describe such role changes as being the most difficult aspect of any educational change endeavor. It is clear that in the case of the Westview science department, the changes have come about in the context of the team planning and peer collaboration that is inherent in what they are doing. Teachers themselves describe this collaboration as having a "big impact." It is one of the keys to understanding the dynamics of educational change in the context of this science department.

Collaboration with other teachers extends beyond the school to a form of networking with other science teachers. Reference is often made by teachers to the benefits of meeting with other teachers through teacher conferences and conventions, as well as in the periodic meetings of teachers in the regional SS&C group, known as a "Hub meeting."

Facilitating collaboration. Given the importance of collaboration for educational change, it is of interest to see what has facilitated collaboration in this particular science department. In discussing this matter with individual teachers in interviews, reference is made to a variety of considerations which will be explored here.

People characteristics. Among the teacher characteristics mentioned as important to their collaborative work, is a tolerance of other person's working styles. Some of the teachers are quite aware of differences in personality and working style, e.g., the desire for structured working plans versus more flexibility. Others make reference to the fact that their peers are adaptable and able to accommodate to other teachers' approaches. There are inevitable conflicts in this arena and one teacher, for example, may feel a conflict between staying on the schedule agreed upon with other teachers, and adapting the plans to meet the needs of students in a way that gets off of this schedule. Such conflicts are inherent in a collaborative venture; being adaptable and accommodating with one's peers is viewed as being important. Specific references often were made to being aware of such differences within the staff. As a result, some are able to refer to a high level of trust among themselves and a feeling that they are skilled in working together cooperatively. Observing the dynamics of a group of three teachers working together in a planning meeting provides insights in this regard. A normal working pattern was for three teachers to get together for a scheduled work session and charge into the task at hand without any one of the three playing an obvious leadership role. Egos did not seem to be a problem. They went to work in a cooperative fashion with no evidence of competition between them nor any apparent need for someone to be in charge.

Strategies to foster collaboration. Among the apparent strategies employed in this collaborative process are scheduling specific times for planning and communication, and working in manageable sized groups. It is also evident that working groups were reformed when needed to fit the circumstances at hand. Such regrouping in one case even resulted in reassignment of the classes particular teachers were teaching to cut down on the number of tasks that individuals had to do and to facilitate working in smaller planning groups. Another strategy that fostered this collaborative climate was Karl's decision to include in the Coordinated Science Program only those staff who at that point in time were prepared to be a part of it. Nobody was forced into it; people got into the program when they were ready or at least willing.

Strategic long range planning. A number of practices employed on a limited basis at Westview, and being pursued for the future in a more intensive manner, have important implications for this collaborative work. Shared preparation periods for people in a given planning team, for example, usually have not been possible but are found to be highly desirable. Efforts are being made in future schedules to overcome the barriers which have prevented such arrangements in the past. A second possibility is block scheduling, an approach with which some of the teachers have had experience in other contexts, but which is now not practiced at Westview. This possibility apparently is being discussed more widely in the school than just the science department and has some noticeable support. Such a change in the schedule would, among other benefits, enhance this collaborative planning.

A third change which is even more difficult to achieve, but would have important implications for collaboration, is a change in the physical facilities. At the moment, teachers are scattered in three different building, and those teachers within a given building are not necessarily right next to each other. Comments by individual teachers make it very clear that collaboration and teamwork is far easier when they have adjoining classrooms and joint working space, but it exists in only a limited portion of the science classrooms.

Resources and Support

When the word "support" is used by school personnel, it generally refers both to (1) administrative actions dealing with tangible financial resources, and to (2) less tangible support such as (a) administrator's endorsement of decisions made at levels below them and (b) being an advocate for teachers when dealing with outsiders or other members of the educational community. Whichever form of support one is referring to, the members of the science department at Westview High School generally have a perception of good support from different levels of administration, although there is some variation according to the type of support being addressed and the level from which this support is emanating.

For example, there is a perception, as described earlier, that state support favors them, but is not totally consistent. Frustration with the teacher certification process as it relates to Coordinated Science, for example, is not perceived as being what it should be. There is an awareness, however, that all educational agencies in their state are operating under tight financial restrictions. While they would like more public support in this regard, there is a sense that this reality tempers what various levels of the administrative hierarchy can do. Even though district level personnel indicated that class size in their district runs somewhat larger than the state average--and individual Westview science teachers will point it out as somewhat of a problem--it does not seem to diminish the overall perception of support that they feel from levels above them.

Regarding district and school administrative support for departmental decisions, there are many statements of feeling strongly supported. They have set out to make a new Coordinated Science program and the perception is that all levels of administration are supportive of what they are doing.

Another category of support pertains to requests they make as a department, that in some way impinge upon the remainder of the school. Two examples stand out. One is their desire for common preparation periods for all the science teachers in the science department, or at least for the teachers in a particular coordinated science level team. A second one expressed by some, especially Karl, is the desire for block scheduling. In both cases, these requests have implications for the way scheduling is handled for the rest of the school. Thus far, requests along this line have gotten nowhere, but enough hope exists that Karl keeps making his requests and pursuing this direction.

Regarding financial matters, the department again generally feels that it has been supported, although there are a number of areas in which funding clearly is not optimum. When it comes to such matters as an immediate need for simple supplies in quantity for all of the particular classes doing the same activities, the teachers seem to get what they need rather quickly. The perception is that Karl will find the money and they will get the needed supplies. At the same time, there is a recognition that some more expensive equipment they would like to have is not available. The supply situation is not bad, but it could be better.

Another need with major financial considerations is improved classroom facilities. Their classrooms are currently scattered among three buildings and the rooms are not well suited for teaching in groupings other that conventional sized classes. It is difficult, for example, to combine two classes for larger group instruction, and some of the facilities are not well adapted for students working in small groups. As in the case of the scheduling request, Karl apparently brings the issue to the table on occasion, although as an outside observer one gains the impression that he does not expect to win this battle as soon as he would expect to get some accommodation in the matter of scheduling.

It appears the department has received financial support for personnel time to as full an extent as they have requested it. Although the amount of released time (through the hiring of substitute teachers) and pay for extra work during the summer is not large as compared to what occurs in some school systems for special projects, there is no indication they have gotten less than they requested. Some of the financial support for this personnel time has come from the district and some from NSF funds available through the SS&C regional center.

One area in which they do not have everything they would want, namely textbooks that fit their curriculum, does not seem to be an issue of support. A number of the teachers would like a "regular textbook" to use with Coordinated Science, but what they have in mind apparently is not on the market. The issue of textbooks is an important one in this case, but current indications are that the issue is not fundamentally one of financial resources.

Systemic Considerations

Thus far in our consideration of what brought about the science education reforms at Westview High School, attention has been given to an interconnected set of national and state influences, local leadership within the science department, the power of teacher collaboration and various aspects of administrative support. These areas clearly are interrelated in a complex manner; none operates in isolation and the degree of influence of any one of them is to some degree determined by how it relates to the other. Thus, understanding this situation makes a *systemic* perspective essential.

This word, "systemic," has become popular in current discussions of educational reform. It is used in many different ways, a number of which probably are not consistent with a social scientist's use of the term in various contexts. Sometimes it appears to be a word used by politicians at the national level to address reform efforts involving political entities at levels other than the national level. In other cases, politicians at a given level, e.g., the state level, may use the term to describe an inter-connected set of political actions which can be taken at that level. More fundamentally, the term addresses the many different facets of a complex system, whether they be political, cultural, social, psychological, or philosophical in nature. It pertains to all components of an organizational system, encompasses the full collection of actions taken by

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different actors in the picture, requires a variety of scholarly perspectives that could be brought to bear on the situation, and does so in a manner that does not ignore how a change in any one element interacts with any or all others. To fully address what has brought about the changes at Westview High School, and extend this discussion into educational reform in other contexts, it is essential to have this systemic perspective.

Coordination and consistency. The Westview case study makes it apparent that specific subject level reforms and more general and broad attempts at reform are related. Such reforms obviously are related to each other, and a systemic perspective requires that everyone take account of this situation. At the state level, for example, *consistency* between the various reform efforts, whether general or specific, is essential in everything that the state does. General reform documents should not be asking for different kinds of reforms than the subject specific documents. Furthermore, the different political entities must all be operating in the same direction. A commission on teacher certification, for example, should not be taking actions that are inconsistent with changes being promoted in a curriculum framework.

At the local level, *coordination* of various reform actions is needed. Leaders of a local school can make substantial gains by coordinating more general reform activities they initiate in their school with those undertaken in various departments. As is clear from the Westview case study, educational reform in a science department may well be very consistent with the broader reforms under consideration by the school as a whole. Much can be gained if local leaders take this into account and leverage their various actions.

Obviously these matters of consistency and coordination require that decision makers have the "big picture." In other words, that they have a systemic view of the situation and understand how the many factors involved interact with each other. To a certain extent, no person has the total picture in mind, and some people in more limited parts of the system are able to function quite effectively with a somewhat limited view. In general, however the better understanding each individual has of the big picture, the easier it is for reform to occur.

IV. CONCLUSIONS AND IMPLICATIONS

Desiring certain reforms and making them happen are very different matters. The means of attaining reform are not certain. There are many barriers to change and strategies for overcoming them are not fully understood. Many dilemmas arise--especially for teachers--in the reform process; tensions arise in facing choices and their accompanying trade-offs. Changes and choices are intertwined with the beliefs and values of all parties, including the teachers, administrators, the community, and the various reform initiators. Exploring the implications of the Westview case for other reformers requires attention to barriers, dilemmas and beliefs.

The following discussion of implications is organized under barriers, dilemmas and beliefs. The three categories are not mutually exclusive--they blend together at many points--but they are still useful. Barriers are obstacles to reform that must be overcome. In general, their removal, e.g., lack of funds for equipment, does not introduce new problems into the school setting. Dilemmas also restrain reform, but the dynamics of removing them are not as simple. They generally involve choices with some form of discomfort or tension no matter what alternative is selected. Choosing to use or not use ability grouping, for example, generally leaves some people unhappy no matter which choice is made. Beliefs about educational matters underlie most dilemmas. A preference for using or not using ability grouping, for example, probably is grounded in beliefs about the context in which various types of students best acquire certain forms of understanding.

Barriers

Barriers to reform generally are a product of powerful institutional and cultural constraints. Political, economic and socio-cultural factors influence their restraining power. Influential barriers to Coordinated Science at Westview High School are explored below.

Time. Discussion with teachers in the Westview science department made it clear that the biggest barrier to change is the time it takes to do it. It is not a matter of time within the school class period in most cases--although teachers at times will talk about certain innovative teaching approaches taking more class time and resulting in less coverage of material--but a matter of time needed outside of class to plan for a new approach and make all the required arrangements. Most importantly, it is the time required working with fellow teachers to plan and coordinate the new venture. This planning and coordination is seen as absolutely essential to the new program, but it also creates a major obstacle to the program because of the time required.

Time for teachers in a secondary school is always in short supply. An outsider to the culture of the institution is likely to be struck with the multiplicity of tasks that teachers seem to undertake simultaneously, and the manner in which they quickly move from one to the other. A teacher seemingly is always ready to answer a quick question in the midst of doing another task, while simultaneously keeping an eye on other activities that are going on.

The basic means by which Westview teachers address this barrier is employing good management skills and working very efficiently. When teachers have a planning session during a thirty minute lunch period there is no wasted time. Attention quickly goes to the central matters at hand with no waiting for someone who is not yet present; decisions are quickly made. The barrier has not been eliminated; Westview teachers have just become skilled in overcoming it.

The need for communication. Along with time, the need for extensive communication is often cited by teachers as a barrier for accomplishing program changes. In fact, the two are often mentioned together since communication is such a time consuming process. In discussions about communication at Westview, reference occasionally was made to personality styles or different ways of working. An important consideration is simple recognition of the fact that these differences exist. This recognition is apparent in statements made by various members of the department. There was recognition of the preference of some teachers for developing well structured teaching plans well ahead of time, while other teachers were happy to finalize plans only minutes before the class began and then change them during the class if there seemed reason to do so.

The need for close teamwork is recognized by all of the teachers involved, although there have been occasional instances in which a needed compromise seemingly was too costly for everyone to accept. By and large, however, the total Coordinated Science Program proceeds on a team basis, with classes of a given year operating together in terms of planning and the activities used within classes. They have created structures within which formal communication can take place and have established a culture in which informal communication is a natural part of the workday.

Parents. Throughout this period of program development, the new classes have been well received by students, and parents have been accepting them. By and large, parents did not become deeply involved in the process and did not have many concerns about what was taking place, with the exception of some continuing concern about whether or not the new program would receive University of California approval for college admission. The approval process was to drag on for a couple of years but the principal was convinced that approval was coming and he and the science department chair were able to calm the nagging fears of the few worried parents.

The amount of resistance from parents to the new science program at Westview High School is small as compared to the resistance to such innovations found in many other schools. Such reluctance, however, must be recognized as a factor in the situation even though it is not a large problem. Another aspect of parental resistance is tied to the absence of a textbook. For some parents, particularly those concerned about seeing their student study at home, the absence of a textbook is problematic. Their image of a serious student is one who brings a book home from school and studies with it.

Another aspect of parental concern pertains mostly to those parents with students who are considered to be particularly able academically:

> I don't think there was worry about subject matter. The concerns were no book; things like well was it college prep or was it honors; were they going to be tracked or untracked ... and there were a number of parents concerned about the UC approval thing.

In most cases parents apparently were not concerned about the actual integration of the various natural sciences into one course, but they did have concerns if their student did not have a book, or was not in an honors or tracked college prep course when they might otherwise have been. While the number of Westview parents with such concerns was quite small, they nevertheless were a factor.

The main response to these concerns was attention to communication with parents--often informally--on the part of teachers and administrators. An additional response to this concern is Karl's proposal to have an honors section of Coordinated Science in the next academic year as discussed below.

State restrictions. Even though Coordinated Science at Westview was established partially in response to the new State curriculum framework for science, and is in line with State expectations, there are State level actions which are problematic, namely the slow University system approval and the difficulties with certification of teachers. The significance of these barriers should not be minimized. While the Westview science department thus far has managed to overcome these problems, they have been major impediments to the reform process. Nothing appeared to create a higher level of frustration for Karl, the department chair, than the intransigence he encountered in this arena.

The process of getting University of California approval took approximately two years. If approval had not been received it probably would have meant the death of the program. The fact that it took so long was viewed as a serious matter.

Another constraint is more directly in the hands of the State Department of Education; it has to do with teacher certification. Unless a teacher has considerable breath in the sciences, the certification process would not give them permission to teach coordinated science. They would be limited to teaching those aspects of science in which they had a certain minimum number of courses. At the present time, this issue still has not been resolved to everyone's satisfaction. Although the requirements for *initial* certification of teachers have been changed so every new science teacher is now qualified to teach coordinated science, there are still many science teachers within the schools who do not have sufficient breadth in the sciences to meet this expectation.

It has been a serious constraint for some teachers. Unless satisfactorily resolved, Karl viewed this matter as a potentially impossible obstacle for the new program. He made reference to the "letter of the law" and the "spirit of the law" and was convinced that without less emphasis on the letter of the law they had serious problems. There are serious limits to what Westview can do to remove this barrier with their current staffing; it is a matter for state action.

Physical facilities. As indicated earlier, the rooms in which science is taught vary considerably in the extent to which they are equipped as science classrooms and they are scattered among three buildings. An initial impression was that this situation did not create much of a problem for them, probably because they seemed to be coping with it so well. Greater immersion in the site, however, pinpointed the facilities problem as the root of other problems to a larger extent than initially realized. The physical arrangements have a major impact on how readily teachers can work together, share teaching materials and engage in teaching practices that involve grouping students in unconventional manners, such as putting two or three classes together for some large group presentations.

Coordinated Science in its early stages had some team teaching but it quickly disappeared when the number of sections of Coordinated Science expanded. Only in the last year has it returned to a small degree with three classes meeting together in an auditorium-like setting during one period of the day on one day of the week (fifth period on Mondays). Obtaining the use of this facility was not a simple matter and it serves as an example of how important physical arrangements are to various innovative patterns that might be employed. The removal of this barrier requires strong administrative support and the cooperation of other departments in the school.

Scheduling. Related to the inadequacies of the physical facilities are various facets of scheduling. Teachers in the science department would like to have block scheduling with more extended periods of time with students. There is some possibility that block scheduling will come about; school-wide discussions on the topic are under way.

More simply, the scheduling issue is a matter of when the Coordinated Science classes are offered within the regular class schedule of the school. Ideally, the teachers would like to have multiple sections of a given year of Coordinated Science (e.g., first year Coordinated Science) occurring in the same class period and have the same planning period for all of the teachers teaching a section of this particular year of Coordinated Science. Such an arrangement has two very important outcomes: (l) it facilitates team teaching and (2) it gives them the common planning period so important for developing communication and teamwork.

What seems to be a relatively easy matter to accomplish apparently is resisted by the administration and counseling staff because it significantly reduces the options available to students in creating their individual schedules. A section of a given year of Coordinated Science simply is not available during as many different periods of the school day under such an arrangement. Thus far, it seems that preference has been given to providing more options for individual scheduling than for fostering teacher collaboration.

Laboratory equipment. As in the case of physical facilities, the first impression was that any lack of laboratory equipment for Coordinated Science was not serious. After all, teachers made comments at times about how effective Karl was in getting additional supplies when they discovered they really had to have them, and no reference was made to any particular laboratory activity not being used because of a lack of equipment. It quickly became apparent, however, that there were many laboratory activities for which there were insufficient sets of equipment to conduct the activity in more than one class during a given period of the day. As a result, when two sections of the same year of Coordinated Science are offered during the same class period, in many cases the teachers have to plan very carefully to make sure they use the equipment on alternate days. When considered in light of the desire to have more team teaching and alternative groupings of students as discussed under scheduling above, it becomes apparent that equipment may become even more of an issue.

There is nothing about Coordinated Science *per se* that creates a need for more laboratory equipment than if science were taught in the conventional manner of biology, chemistry, physics, etc. The equipment issue arises due to the increased enrollments in science and the creative ways of which teachers want to cooperate for instructional purposes within this program.

Karl was of the opinion that most of the extra funds they have gotten for initiating Coordinated Science had come from or through the state, with only a couple of thousand dollars coming out of the school budget over a period of years. When considered in connection with the scheduling issues it appears that there are actions which could be taken by the school administration that could assist the Coordinated Science Program. Thus far, Coordinated Science seems to have thrived in the midst of a very decentralized approach, with Karl and the teachers expressing considerable satisfaction with the freedom they have had to develop their program. Other direct support from the school administration would seem to have important potential benefits, if these actions are possible in the midst of all the competing demands placed upon the school administration.

Staff turnover. The previously mentioned staff turnover between the 1992-93 and 1993-94 academic years was a significant matter; the department coped well with the situation, but it clearly was a setback. Their means of coping have been great care in hiring and Karl's dedication to assisting the new people to get underway. In one sense the program moved right along in spite of the staff turnover, in that Third Year Coordinated Science was offered for the first time during the 93-94 school year. But it also is clear that the department as a whole had to relearn aspects of working together and there was a significant loss of expertise from the people who left. This loss is particularly apparent in the third year course:

> If there was a setback I think it was in the ... the third year program because Vicki had the vision for the chemistry part of that.

While Bill Niemeyer, the new teacher who worked in third year Coordinated Science, did an admirable job, the expertise of the experienced teacher who had originally planned much of the course certainly was missed.

The ability of the department to survive this massive turnover is very impressive, but there is no doubt that the total program will not reach its potential as quickly as if the turnover had not occurred. The staff changes, for example, have reduced the level of enthusiasm of some teachers who are missing the collegiality and expertise they no longer have from their experienced colleagues. There is a certain momentum that needs to be maintained in the face of continual demands on teachers' time that is generated through their collegial relationships. The loss of these relationships was significant and it reduced teachers' ability to move further into more innovative teaching approaches. The means of overcoming this barrier was persistence, patience and hard work.

Dilemmas

Many perceived barriers are dilemmas that do not have a simple answer. Whatever choices are made, some dilemmas have no simple solution. The role of textbooks, ability grouping and assessment at Westview are illustrative of such dilemmas.

What should be the role of the textbook? The absence of a textbook that can be used in the conventional manner for the Coordinated Science Program is perceived by most of the teachers as a significant barrier, in spite of the fact that they have been able to make several accommodations to the situation and operate without them. This concern for lack of a textbook is reflected in numerous comments from teachers, and it is recognized by Karl as important to the people in his department: "The hardest thing for some of them was not to have a book."

Although having sufficient funds to buy textbooks as needed on a frequent basis is a financial matter of some concern in this school district, the fundamental issue is not a lack of money to buy the books. It is a matter of the availability of a suitable text that fits the Coordinated Science Program. Although such books may be in the process of coming on the market, a suitable one in the eyes of the staff was not available at the time they began their program. Various accommodations have been made such as purchasing quantities of a variety of books for classroom use and the authoring of "textettes" by Karl for selected parts of the program.

Various teachers analyze the textbook situation in different ways. Some see it as primarily a matter of how they carry out their instruction, while others see it as a matter of dealing with students or parents. Betty Cronin, for example, said that: "It has been a hindrance in terms of dealing with students and parents, not curriculum wise."

Linda Voss, on the other hand, uses language that on the surface sounds somewhat similar but reflects more of concern for the impact on her actual instruction. Without the textbook, it apparently was harder for her to see the overall picture of the instructional schedule, particularly in her first year of teaching Coordinated Science. This in turn was reflected in the classroom dynamic: "And like I say, the kids get -- getting stressed out about not having a book, and that is hard for me."

Other teachers talk about it in terms of the direct impact on students, particularly in terms of whether or not they have a textbook to take home with them to study outside of class. Opinions in this matter vary among the teachers, and even seem to have varied over time:

> I'm beginning to waffle on that, for my original idea which was first I hated not having a textbook, then I said, oh it's great, it's fine, and textbooks are so limiting, and then to have Karl write up a little textette. It was real nice to be able to come back to that and tell the kids, okay you need to read these pages because this is the basic information we are talking about and if you don't understand what I talked about in class then go back because you will find it there in greater detail. And I think for all but the most conscientious and ambitious students at this point, I would say it really is a help to have the textbook.

The differing opinions about the textbook also appear to reflect different persuasions about how student learning can best be fostered in a class. The extent to which teachers see knowledge as something for students to acquire versus conceptions that they must construct is reflected in their comments, although this sort of pedagogical distinction was not an observed topic of conversation. There appears to be some recognition of it on Karl's part who, in expressing his lack of agreement with some members of the department on the importance of having textbooks, would associate textbooks and worksheets.

While the coming to market of new textbooks suitable for Coordinated Science may remove this dilemma for Westview, the underlying pedagogical issues will not go away with the arrival of such books. These issues are rooted in teacher beliefs to be discussed below.

Detracking. Ability grouping and tracking of students have generated considerable controversy in many quarters across the country. There are differences of opinion at Westview also, although the intensity of such disagreements is at a relatively low level. Significantly, the issue is not very visible among parents, based on what teachers report. Teacher reports varied from one who never had a parent express a concern about the fact that Coordinated Science was detracked, to a teacher who was aware of one or two parents who had questioned the practice or expressed some concerns.

The topic obviously had been of more intense discussion among the science department teachers. There is considerable variation in opinion among them, although it does not seem to be a contentious issue that in any way effects their working relationships. Julie, for example, would opt for a tracked approach if given her personal choice. Representative of the other end of the continuum is Karl, the department chair and teacher with whom Julie worked most closely--in some cases actually teaming--in second year Coordinated Science. He does not see tracking as the answer to meeting individual differences among students and he is quick to point out that he not only favors the absence of tracks, but it is consistent with the California Science Curriculum Framework. He also notes that the district is in favor of their untracked approach and that their Coordinated Science courses are district approved courses.

Someplace in the middle is Betty, who sees both advantages and disadvantages to each of the alternatives, and vacillates at times as to what approach she really thinks is best: "It depends, honest it depends what day and how the activity went the day before or what we are trying to do."

She is excited by the fact that there are students signing up for the third year of Coordinated Science whom she is convinced would not be taking a third year of science if they were in a traditional tracked science program. She referred specifically to students getting C's in her second year Coordinated Science Program who are planning to take a third year of science because they "see a value to the class" and she finds this "exciting."

Betty is torn, however, between a concern for her most able students in their future college careers, and the more middle of the road students who may succeed in the future in a way they would not have, if they had been restricted to lower level tracked courses. She also notes that the heterogenous grouping of her Coordinated Science students has "stretched me as a teacher." She indicates it has pressed her to look harder for more hands-on activities and to make certain concepts more concrete for students who are having difficulty.

Betty's coping actions are an apparent attempt to deal with some of the tensions found within a detracked program; there are other coping measures which are more institutional and less dependent upon the individual teacher. For example, Karl has submitted a course description for approval which would establish an Honors Coordinated Science class. It is an attempt to meet the needs of the more able students within the context of the heterogeneously grouped Coordinated Science classes. Honors students would not be grouped into a separate section; they would still be mixed in with other students in a regular Coordinated Science class. Within the policies of their school, this is the nature of an Honors course. The understanding is that an Honors student does some qualitatively different work (in contrast to more work) within the course by engaging in different assignments and learning activities. Such work is expected to be more challenging and demand more of the student.

Apparently, the existence of an Honors designation within the Coordinated Science Program is important for encouraging the most able students to enroll in Coordinated Science, instead of the traditional science program. Within the traditional science program there are currently three courses with an Honors level, Advanced Placement Biology, Physics and the First Year Biology course. High level achievement in an Honors class gives the student a higher grade point average, and thus there is an incentive for the high achieving student to seek out classes with an Honors designation.

Detracking, heterogenous grouping and related issues are not just matters of student learning and teacher job satisfaction. They have implications for the survival of certain kinds of innovative programs such as Coordinated Science.

How to assess. Alternative assessment as an issue at Westview largely is a matter of time. Philosophically, most teachers favor it. Many are so strongly committed to it that they devote major amounts of time to it. Others are not ready to devote any more time to it than necessary because they view other aspects of reforming the science program as more important and the time pressures of the new program are large.

As the time pressures of initiating a new program lessen over a period of years, the new forms of assessment probably will become more prominent, especially given their favor among some teachers and their consistency with the overall nature of the new science program.

Beliefs

Many dilemmas are grounded in beliefs--beliefs that may or may not be well-founded. The commonly accepted values, beliefs and practices of the society found within a given school or community form a common culture which typically is a powerful constraint to change. Individual teachers also have varied beliefs. For example, their beliefs about the efficacy of such practices as heterogeneous grouping of students vary; a constructivist view of learning and teaching is far from universal among professionals in the schools; and many professionals place socialization goals above intellectual development goals (Stake & Easley, 1978). Two important areas of belief at Westview are addressed here.

College preparation. Although the Westview science teachers generally are committed to the idea of teaching selected topics in depth rather than covering a larger number of topics more superficially, many of them feel a tension between this approach and a perceived need to "cover" an abundance of topics for those students going on to higher education. Betty Cronin, for example, expressed some discomfort about the fact that the chemistry studied in her second year Coordinated Science class did not go into as much depth on stoichiometry as she would have preferred:

> They have balanced some equations, but the chemistry teacher in me still wants to see a whole unit on stoichiometry where, you know, they have balanced a whole lot of equations and they have gone through mass conversions and mass mole conversions. And because I know they are going to have to do that in college, and I guess I would feel more confident that the kids would be successful if they had to do more of that stuff here.

As the conversation continues, however, her reflections bring to the surface the fact that by the end of the second year of Coordinated Science the picture is not complete because chemistry is spread out over the three years of Coordinated Science. There is more chemistry to come the next year. Still, the worry does not completely disappear; she is worried about her most able students who she feels may go on to college without the depth of preparation she is convinced they will need to succeed.

A little probing indicates that she is not aware of the many studies which have been done to compare the success in college chemistry courses of students who did and did not take chemistry in high school. Although these studies show very little correlation between success in college chemistry courses and whether or not the students had or had not taken a high school chemistry course before hand, knowledge of this research would not necessarily change a deep-seated belief in the importance of "coverage." What Stake and Easley (1978) called the "preparation ethic" is widely held among science teachers, including Westview teachers. Resolving some of their dilemmas may require the teachers to grapple with the validity of some of their beliefs.

Lack of constructivist orientation. While different educational reform endeavors give greater or lessor attention to what is often called a constructivist perspective on learning and teaching--and have somewhat different conceptions of what this perspective is--it is nevertheless an important, underlying, conceptual orientation of science education reforms such as that of Westview. There is considerable ambiguity as to the influence of a constructivist perspective at Westview, and the degree of influence is not particularly large.

Constructivism is not a major operating guideline at Westview, although elements of it are present. The major ideas of this outlook (not just terminology used in conversation), are not evident as a major theoretical perspective in teachers' thinking. A number of instructional approaches used at Westview are consistent with this outlook, but they appear to be used on a very pragmatic basis, in so much as they seem to work well and students like them, rather than because they are consistent with some foundational perspective on how students learn. For example, cooperative grouping, a large number of laboratory activities, a de-emphasis of lecturing, and a commitment to having students figure out ideas for themselves are favored by the teachers, but there is little indication of a theoretical understanding or conceptual framework that relates these specific instructional techniques.

Constructivism as a term did not come up in any conversations at the site and other than a reference to having kids figure things out for themselves, Karl is the only one who mentioned ideas that appear to deserve the label "constructivist." His description of his understanding of learning is used as a rationale for the way in which the curriculum is organized, but his conversations do not indicate it is a basis for his approaches to teaching.

Karl's constructivist ideas appear to be connected to a book he read about human learning:

> Until I read that book, I thought that the best way to present something was in a logical ... my logic, anybody's logic and if this makes any sense, kids follow ... well his (author of the book) whole precept is if you don't have a pattern existing already in your brain that you can match something to, then you are not going to learn it until you have a pattern established.

He now is convinced that significant learning is not something a student does by filling out a worksheet or answering specific questions for which the answers are found on the printed page.

When asked if this outlook was something that he and the other teachers ever talked about much among themselves, he responded that it had some role in the beginning. When asked on another occasion whether this thinking about teaching and learning was consciously a part of how the teachers in his department looked at it, he responded that "if it's conscious, it's only in Vicki and Julie and myself."

The use of concept maps is related to a constructivist orientation to learning and teaching. When their use was observed in one class, the topic was pursued in interviews with other teachers. In most cases they either did not even know what concept maps were, or if they did, they had only a nodding acquaintance with them. Those few who did have some awareness of concept maps, saw it as just another technique and not something integral to their philosophy of making connections for students among various science concepts and their applications.

Roughly half of the science teachers in the department (prior to the large turnover during the summer of 1993) appear to have little grasp of constructivist rationales for teaching practices and the other half have a limited grasp. They felt it was important that their instruction be set up in a manner that helped kids to make connections, and there was a tendency to put some of the responsibility on the students for making these connections, but by and large their rationale was not much more sophisticated, and there were few indications of tying this rationale to very specific teaching practices. Given the orientation of current science education reforms, the predominant beliefs about teaching and learning may represent a barrier to further movement toward reform in this school.

The Future

Many beliefs have changed in the context of the collaborative working relationships of the teachers. More beliefs potentially will change as this collaboration continues. It is the key to continued reform.

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CASE STUDY OF EDISON HIGH SCHOOL

STEPHANIE QUATE
CURRICULUM REFORM PROJECT
UNIVERSITY OF COLORADO

This paper was prepared for the Curriculum Reform Project, a study of curriculum change in mathematics, science and critical thinking which is funded by a grant from the U.S. Department of Education's Office of Educational Research and Improvement (OERI Grant #R91182001). The opinions expressed herein are those of the author and the participants in this study.

FOREWORD

When faced with a challenge, a detailed story of someone else's experience in a similar situation generally is of strong interest. In reading someone else's story--be it political history, a chronicle of dealing with a family tragedy, or the story of a major business success--we do not expect to find a formula to apply directly to our own situation; instead we hope to find insight and inspiration. Thus, the story contained in this report should be engaging to individuals committed to educational reform in a local school context. It is the story of one school--or department within a school--engaged in fundamental reform of education for its students.

Similarly, one should not expect to find in this case a model for a specific educational reform to initiate in another locality. Every context is different. Each local school and community culture has its distinctions, each individual's and group's educational goals have different shadings, each setting has its own history, and each school has unique constraints to making change.

Not only does one formula not fit all schools, there is no specific formula for a given school. A central message of our case studies is that educational reform is a long-term process for which there is no detailed road map. It is an uneven process with highs and lows, failures and successes, but gradual movement toward greater and more profound learning for students.

What we can expect to find in this story are insights about new teacher roles, how students go about learning with greater depth of understanding, the context in which such shifts can occur, the challenges that must be overcome to initiate these changes, and actions taken by various parties to keep the process of change moving forward. Reflecting on someone else's story can be helpful in the process of developing one's own plans, collaborating with others to move the process forward, and helping students take responsibility for learning.

The Research Project. The case study reported here is one of nine--three each in science, mathematics and higher order thinking across the disciplines--conducted as part of the Curriculum Reform Project. The cases were studies of individual schools--actually a department within a school in the case of science and mathematics--in the process of solidifying reform. Each was selected because it was a successful example of reform. A researcher spent 20 or more days at the site to learn what changes they were making, the barriers encountered, how they overcame these challenges, the nature of their successes and their hopes for the future.

Site Selection Criteria. Sites were sought which had initiated reforms consistent with those recommended by leading groups in the respective field, e.g., the Curriculum and Evaluation Standards for School Mathematics (Commission on Teaching Standards for School Mathematics). Final selections were based on program outcomes including student test scores, enrollments in subsequent elective courses in the given subject area, and professional judgments about the quality of the curriculum provided to students.

Site Selection Process. The search process began with the solicitation of nominations from researchers and knowledgeable practitioners across the U.S. Key people at the nominated schools were contacted by phone to get additional information and written exchange of information followed. Selection according to the above criteria resulted in schools spread across the country with considerable variation in location (e.g., urban vs. rural), economic level and ethnic makeup of the communities.

Research Methodology. In each case the researcher was immersed in the activities of the school and collected a wide range of information. Data included classroom observations, interviews with students, teachers and administrators, and a variety of documents from the site. The voluminous field notes and interview transcripts were analyzed and an interpretative report written.

Cross-Site Analysis. A cross-site analysis of the nine cases was conducted to gain perspectives that extend across the sites. An individual case is rich in description and context but does not contain the depth of analysis that can come from looking across a number of cases. Thus, the reader is referred to the Project's cross-site analysis. Main points from this analysis to bear in mind while reading this one case, however, include the following:

- The reforms being sought are profound and demand major changes in teacher and student roles.
- The process for achieving such reforms is complex and demands a long period of time to attain.
- The schools in these cases have traveled a considerable distance on the road to reform but have not yet "arrived."

These cases are presented largely--though not exclusively--from the perspective of the teachers at the center of the cases. This perspective reflects the nature of the reforms and the way they have been initiated in each school. This perspective may be particularly important for initiating change. Our cross-site analysis shows that changes in teachers' values and beliefs--not just greater teaching skills and techniques--are central to reform. While changes in student roles and student work are the ultimate "bottom line," these teacher changes are an important intervening step.

We hope your reading of this case stimulates both interest and significant reflection about reform activities in your school.

Ronald D. Anderson
Director, Curriculum Reform Project
University of Colorado

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I. INTRODUCTION

Within the last few years, several states have developed legislation which supports the goals of schools working at changing conventional structures and practices. Because of the systemic nature of these reforms, such states and their schools hold promise for others. A few years ago one such state legislature mandated a complete overhaul of the educational system. Schools that do not substantially improve stand to lose revenues and jobs. The consequences are serious, and the schools are taking the mandate seriously.

This state's Supreme Court declared its entire state's school system unconstitutional because inequitable funding and nepotism blocked access to an adequate education for many of the state's students. The following year, the School Reform Act (SRA) was signed into law. This mandate is one of the most comprehensive and far-reaching laws of its kind.

The major assumption underlying SRA is that all students are capable of learning. Rather than promoting the notion that only the elite few can master higher order thinking skills, SRA demands that all students successfully achieve high performance standards. The foundation for SRA is three-fold: a focus on learning that matters, the creation of contexts that are authentic, and the insistence that students demonstrate their knowledge.

How does this mandate change the way teaching and learning is carried out on a day to day basis in schools? That is the question this case study attempts to answer. To better understand how one school is dealing with changes in teaching and learning, researchers visited Edison High School, which has been widely noted for its reform efforts.

To understand the implications of this reform effort, researchers completed extensive analysis, looking for recurring themes and patterns with the aim to compare the goals of the school with the practices in the classroom. Classroom transitions were described on a continuum of practices and compared to school intentions.

Data Collection

Researchers visited Edison High between early October and late January. Data were gathered through interviews, artifacts, and field notes. Several classes were observed over this time period. When observing classes, researchers interacted with students, sitting at tables with them, listening to their often secret conversations. In addition, considerable time was spent roaming the halls of the school, visiting other buildings within the school complex, and talking to teachers from other programs. To get a wide view of the reform efforts, researchers interviewed key players at Edison: students, teachers, the principal, a parent, the district's director of curriculum, and a staff developer from the teacher training center. In addition to interviews, researchers attended numerous meetings, including teacher planning sessions, three staff meetings, two staff development training sessions, and a parent meeting which introduced the concepts of the state reform effort.

Artifacts collected over the four month period included student work ranging from journal assignments to major performance assessments. Since presentations are an integral part of the reform effort as conceived by the two focus teachers, presentations were tape recorded whenever possible.

The team of teachers who form the basis for the case study were selected for several reasons. First, they were experienced with the reform effort. Both had received additional training in pedagogical practices advocated by the Coalition of Essential Schools and both were noted as exemplary teachers. Their formal training included work on thinking skills, and often visitors were invited into their classroom to see how an emphasis on thinking was integrated into their work. In addition, this team had been in existence for several years and was often pointed to as a model teaching team. Finally, their teaching situation was innovative. The two teachers, Nancy Morrow who is an English teacher and Anne Howard who teaches social studies, taught in an interdisciplinary program, American Studies Program (A.S.P.). Together with four other teachers who form other A.S.P. teams, they plan and design the curriculum.

The Site

Garrison Consolidated School District (GCSD) is a very large school district with approximately 100,000 students. It serves more than 150 urban, suburban, and rural schools, of which approximately twenty are high schools. According to school data, the students are: 31% minority, primarily African American, 46% eligible for free or reduced meals, and 29% members of single-parent households. The average per pupil annual expenditure is $4,550.

Tucked away from the hubbub of the nearby metropolitan city, Edison High School is encircled by thick woods and parking lots. The red brick rectangular building looks like many high schools: an attempt to be friendly but enshrined by the cold efficiency of modern design. Described as an urban, rural, suburban school, Edison fits all those descriptors. The country scenery belies the proximity to the city, only a few miles down the turnpike. Students are bussed in from the city, some from nearby suburbs, and another portion walk to school.

The 1,200 students span grades 9 through 12 and represent a wide range of diverse ethnic backgrounds. Afro-Americans make up a large portion of the minority students with 27% of the school's Afro-Americans coming from the city's projects. The skills of the students as measured by the CTBS tests indicate that the mean of the school is in the thirty percentile range for reading, math, language arts, and science. In social studies the mean is slightly lower, 28%. Close to one third of the students work more that twenty hours a week, and slightly more than half (54%) claim to spend less than one hour a week on homework. Over the last four years, Edison has seen a decrease in the dropout rate. In 1990, the dropout rate was 8.61% while in 1993 the rate dipped to 4.84%. Likewise, academic grades have risen. Four years ago almost 18% of the students earned A's while last year 21% did. The staff at Edison credits work with the Coalition of Essential Schools for these changes.

Background Context

SRA. In order to better understand the changes occurring at Edison, it is necessary to step back and get a broad picture of the educational climate in which the school exists. On the state level, the Department of Education sees its mission as "the national catalyst for educational transformation ... to ensure each child an internationally superior education and a love of learning through visionary leadership, vigorous stewardship, and exemplary services in alliance with schools, school districts, and other partners." SRA is the vehicle for creating this climate for change. Since SRA is an attempt at systemic change, various programs are mandated by law to ensure that all students will be able to meet the high expectations demanded by the reform, including:

- Professional development. Teachers receive training monthly on inservice days, commonly referred to as SRA Days. The work on those days ranges from learning how to ask open ended questions to how to teach thinking skills;
- Expanded technology. Not only will technology become part of the learning situation in all schools, but it will also help collect information from the districts around the state;
- "After Hours." This program provides additional time for students to be successful in meeting the performance outcomes. Students may attend school either in the evenings or during the summer in order to meet the state standards.

At the heart of SRA is the assessment program. Along with holding students accountable for demonstrating mastery of content, teachers are also accountable for the quality of student learning. Based on a complex formula, each school is required to raise the scores of students on the three major assessments to reach a target score. Any school that fails to achieve this score within two years is publicly censured and teachers are placed on probation with the threat looming over them of loss of monetary rewards and jobs. The results of the first round of tests revealed the enormous task that lies ahead for the state. Roughly 90% of the schools in the state needed to make substantial effort to meet the standards. Those first scores indicated that only 10% of the students are proficient or distinguished.

The state assessment program monitors student and school progress toward the long list of learning goals. It consists of three parts: a portfolio, a written test, and a performance task. Students must complete a portfolio in math and English. Originally the law mandated that in grades 4, 8, and 12, the math and English portfolios would be evaluated. Recent changes have moved the math portfolio up to 5th grade and switched the high school portfolios to 11th grade. Students in the three targeted grades complete the written test, which the previous year consisted of 160 questions, 16 of which were open-ended. These open-ended questions accounted for 80% of the student's score. For a performance task, students were placed in groups to complete a task. They were assessed on group skills as well as the quality of their work.

The District Context

The Department of Curriculum and Instruction at GCSD has responded to the challenge of helping students achieve well through mandating various programs, including:

- Advance Program: the gifted and talented program;
- African-American Studies: through a gradual process, African-American studies will be infused into the K-12 curriculum;
- Framework for Curriculum Design: an inservice program that provides training for use of the curriculum guide which identifies core learnings for all areas and suggests strategies for implementing SRA.

As a result of SRA, the Department of Curriculum has redefined its role. No longer is the staff in the position of mandating curriculum; their mission has changed to the facilitation of site-developed change that supports the curriculum framework and helps teachers internalize the framework. In the past, personnel in this department were content area specialists. Staff development had been mostly handled elsewhere, but now more of the staff development responsibilities are in the hands of this department. The move to staff developers meant personnel had to develop new methods of instructional delivery since traditional methods of delivery conflict with the intention of SRA.

SRA demands that teachers learn new roles and develop new teaching strategies. For example, deficiencies in group skills become most apparent on the assessment; hence, many teachers feel compelled to learn cooperative learning and other group skills. Peterson Academy is one structure in place to support teachers in this change process. Funded by a private foundation, this professional development center was designed to nurture innovation. Even though it is part of the district, it is operated strictly on voluntary participation. Following the model of corporate America, Peterson provides staff development which includes reward structures unknown in most American school districts. The brainchild behind Peterson Academy explained, "Obviously, I'm committed to the notion that teachers ought to be treated as executives."

School Context

Edison's main office feels more like a home than the cold, impersonal offices of most schools. Artificial plants sit on the shelves of antique-looking furniture and fill the ledges behind the secretaries' desks. A cabinet against one wall is lined with trophies and other mementos. Placards fill one shelf, each stating an accomplishment and belief of the school: Public Safety Magnet, Coalition of Essential Schools, Learning Choice School, and Success for All Students.

Behind the counter and down a hall is the office of the principal, Maxine Grant. Tough, tireless, and determined, Maxine has been the torchbearer of the Edison's vision of reform. "When I first got here, I knew we had to do something. At that time I hadn't heard of the Coalition of Essential Schools. I just went for pockets of readiness. I looked for those people who I could ask 'What would happen if—.' Then I looked for silos of power. The culture of a high school is tough to change. In fact, we're wrong when we talk about restructuring. What you have to do first is to unstructure. But talk about chaos! It takes a special person to tolerate that situation."

Educational reform has provided one means of containing the chaos. Edison's definition of reform encompasses two mutually supportive sets of goals. First, its goal is to address the state's call for reform. Since Maxine was a key builder of the legislation, the school's beliefs are mirrored in the mandates of the state law.

The second set of beliefs defining Edison's reform efforts can be found in its seven year association with the Coalition of Essential Schools (CES). CES is a reform movement led by Ted Sizer that focuses on a set of common beliefs. In "Edison High School: An Essential School Where Success is No Longer a Secret," a booklet that explains the values and practices of the school, the connection to the principles of the Coalition of Essential Schools is explained:

> The Common Principles that provide the framework for our collective endeavor reveal an ideology about schooling and learning that places "personalization" high on the list of imperatives ... Such a vision, of course, presupposes certain aims of education. We maintain that the focus of a secondary school program should be on helping students to use their minds well and that a high school graduate should have the ability to show his or her knowledge and skill -- to "exhibit" mastery -- in a variety of areas deemed important by local and external authorities. This suggests that the high school diploma should signify genuine competence, specifically in the areas of reading, writing, and fundamental mathematics ... This is the philosophical bedrock of the Coalition as spelled out in the Common Principles.

The nine common principles that guide CES schools are:

- the school should focus on helping adolescents to learn to use their minds well. Schools should not attempt to be "comprehensive," if such a claim is made at the expense of the school's central intellectual purpose;

- the school's goals should be simple: that each student master a limited number of essential skills and areas of knowledge. While these skills and areas will, to varying degrees reflect the traditional academic disciplines, the program's design should be shaped by the intellectual and imaginative powers and competencies that students need, rather than necessarily by "subjects" as conventionally defined; the aphorism "Less is More" should dominate; curricular decisions should be guided by the aim of thorough student mastery and achievement rather than by an effort merely to "cover content;"

- the school's goals should apply to all students, while the means to these goals will vary as those students themselves vary. School practice should be tailor-made to meet the needs of every group or class of adolescents;

- teaching and learning should be personalized to the maximum feasible extent. Efforts should be directed toward a goal that no teacher have direct responsibility for more than eighty students. To capitalize on this personalization, decisions about the details of the course of study, the use of students' and teachers time, and the choice of teaching materials and specific pedagogues must be unreservedly placed in the hands of the principal and staff;

- the governing practical metaphor of the school should be student-as-worker, rather than the more familiar metaphor of teacher-as-deliverer-of instructional services. Accordingly, a prominent pedagogy will be coaching, to provoke students to learn how to learn and thus to teach themselves;

- students entering secondary school studies are those who can show competence in language and elementary mathematics. Students of traditional high school age but not yet at appropriate levels of competence to enter secondary school will be provided intense remedial work to assist them quickly to meet these standards. The diploma should be awarded upon a successful final demonstration of mastery for graduation—an "Exhibition." This Exhibition by the student of his or her grasp of the central skills and knowledge of the school's program may be jointly administered by the faculty and by higher authorities. As the diploma is awarded when earned, the school's programs proceed without strict age grading and no system of "credits earned" by "time spent" in class. The emphasis is on the student's demonstration that he or she can do important things;

- the tone of the school should explicitly and self-consciously stress values of unanxious expectation ("I won't threaten you, but I expect much of you"), of trust (until abused), and of decency (the values of fairness, generosity, and tolerance). Incentives appropriate to the school's particular students and teachers should be emphasized, and parents should be treated as collaborators.

- the principal and teachers should perceive themselves as generalists first (teachers and scholars in general education) and specialists second (experts in but one particular discipline). Staff should expect multiple obligations (teacher-counselor-manager) and a sense of commitment to the entire school;

- ultimate administrative and budget targets should include, in addition to total student loads per teacher of eighty or fewer pupils, substantial time for collective planning by teachers, competitive salaries for staff, and an ultimate per pupil cost not to exceed that at traditional schools by more than ten percent. To accomplish this, administrative plans may have to show the phased reduction or elimination of some services now provided students in many traditional comprehensive secondary schools.

As one of the first CES schools, Edison uses the principles for guidelines, especially those that promote the student as worker, personalization of instruction, and intellectual rigor. As Maxine stated, "If you keep putting the principles up as an innovation design and keep saying we are committed to these things, you can't go wrong. You are back to a student-centered classroom."

Edison has been at restructuring for seven years. When Maxine first came to Edison, half the teachers were within three years of retirement. They had seen the school go from "good kids" to a school filled with students from poor socio-economic situations. At that time, no student teacher would be sent to Edison. Maxine began asking the tough questions. "Why," she wondered aloud, "do 69% of the freshmen fail science? What are we proud of? What can we do differently?" However, she did not propose solutions. The very burned-out teachers had seen "lots of idiots" come through the doors who worked at controlling the teachers in hopes of controlling these students. These principals were "sin-eaters who took on everyone's sins." Maxine rejected that role. "I knew we needed to push forward and I was not about to be a sin-eater. Ideas must come from others. A principal needs to do more seeding than leading. People have to own the ideas. I guess you could say I planted seeds early on."

The school has grown and changed as a result of an infusion of money from grants, teachers with innovative ideas, and nudges from legislation such as SRA. Maxine boasts that in her building there are now more teachers willing and open to change than probably anywhere else in the state; however, she admits, change is slow and filled with impediments.

The change process requires acknowledgement of its nature: its slowness, its tendency to become stagnant, its need for a clear vision, and its requirement for renewed leadership. Without switches in leadership, even the best innovation stales. New leaders bring fresh ideas. Acknowledging the length of her tenure and her influence at Edison, she commented that it might be time for a new principal. At the end of the school year, Maxine did announce to the staff that she would be leaving Edison to work with a leading reformer in education.

At Edison the goals of the three structures--the state, the district, and the school--intersect. As the day-to-day realities of the reform are played out, they are influenced by all parts of the school system. The detailing of student successes, the teachers' struggles, and the challenges promises to provide information for schools and states embarking in similar directions.

II. THE REFORM CURRICULUM IN PRACTICE

The curriculum at Edison reflects both traditional and very non-traditional subjects. Along with familiar offerings of algebra, physical education, and biology, the curriculum includes several interdisciplinary courses at nearly all grade levels. In 9th grade five regular program teachers and a special education teacher work with over one hundred students daily. The teachers design the curriculum and structure based on the needs of the classes. In the tenth grade a team of three teachers integrate English, math, history, science, and public safety. In eleventh grade, A.S.P. integrates American literature and American history. A.S.P., the integrated program with the longest history at Edison, provides the focus of this case study.

A.S.P. is housed in a unique setting: a large open space approximately the size of an elementary school library divided into four quadrants. A classroom is tucked into three of the quadrants, and a work space with desks and computers is in the fourth area. Walls separate each quadrant; however, each of the rooms opens up into a common area in the center. When people walk into the A.S.P. room, they are greeted by this common area. At the end of the common area are windows overlooking the parking lot. A sewing mannequin, often dressed in clothing reflecting the historical period under study, stands in front of the windows. Off to the right is one of the classrooms, and next to it is the work area. The other two are on the left side of the room. These rooms are decorated in the oddest fashion: dummies dressed in overalls recline above bookcases, banners hang from the ceiling, student work covers the walls. Since none of the rooms have doors, whatever happens in the classrooms can be easily seen and often easily heard by the other classes.

Between forty and sixty heterogeneously mixed juniors spend two hours of their daily schedule in A.S.P. Frequently the students are divided into halves, with one group studying history one hour and then moving into the English. The other half reverses this arrangement. Occasionally the entire group of 60 meets in one large group for special events.

A Conceptual Framework

An in-depth look at curriculum reform at Edison High School can be facilitated through the use of the two philosophies which guide the reform: the state mandates outlined by SRA and the nine common principles of the Coalition of Essential Schools. Because of the way in which one philosophy echoes the other, to look at one is to look at the other. One can see the commitment to both these philosophies by what is on the walls of the school -- sets of essential questions reflecting the beliefs of CES and posters showing levels of proficiency for SRA. Teachers wear tee shirts that affirm their connection with CES, and the students have copies of the requirements for SRA. However, the posters and tee shirts do not necessarily reflect the substance of the reformed practices. To understand the impact of new practices if they have become an integral part of the culture of the school, it is necessary to take a close look at the classrooms.

First, however, it is imperative to recognize the complexity of the change process. The goals of CES and SRA promote change in traditional school structures, challenge beliefs that underpin familiar practices, and encourage the development of new teaching strategies. At Edison, structures affecting isolation of teachers and subjects, as well as the constraints of time, had changed because of CES, hence, occurred before the implementation of SRA. School subjects, often taught in isolation of other disciplines, were conceptualized through the lens of integration. In a collegial setting, teachers of various subjects plan daily lessons, major units, and assessments for a common group of students. A.S.P.'s classroom with its open areas that connect to the various teaching spaces makes teaching very public. The teachers in the interdisciplinary settings work in long blocks of time that they, rather than the bell, can control based on curricular needs. The deliberate structure of the school then was developed in order to facilitate the goals of reform as envisioned by the common principles and later as mandated by SRA.

Each of these changes creates something new for teachers to learn since, along with structural change, beliefs with long histories in the educational culture need to shift, particularly the implicit belief in behaviorism that underpins familiar practices. For example, some teachers -- as well as students and parents -- believe that learning to read is a process of gathering the skills necessary for successful decoding. This belief prompts practices such as the use of worksheets on syllabication or other "skill and drill" assignments. In such decontextualized settings, skills are stressed before the making of meaning. In contrast, more recent theories on reading build from constructivism that promotes meaning first and relegates skills to context. Skills are not abandoned; rather their position in the curriculum is altered.

Another change in beliefs is highlighted by the collaboration at Edison. Many teachers tell stories of schools in which ideas are jealously guarded. Teaching ideas became the property of the teacher, not to be shared by others. Files were locked, and doors closed so that colleagues could not see what was happening in their rooms. In contrast, at Edison many of the teachers plan together, sharing and critiquing each other's ideas. The removal of isolation, however, makes the teachers vulnerable. Because of collaboration, teachers need skills for negotiation and for successful teamwork, skills not as essential in the traditional setting. At the same time, teachers in a highly collegial atmosphere can return to their own classrooms, and if the setting permits, close the door and work in isolation. Both aspects of openness and isolation can co-exist.

Reforming school, then, demands new ways to think and act as well as a recasting of old ways. Any examination of the day-to-day life of a school in a reform process must address this complexity. The framework Parsons (1995) has designed for examining educational reform acknowledges this complexity and resists the simplistic orientation that a school involved in reform has completely stopped all traditional practices. In a presentation at ASCD (1995) and earlier in an article (written in 1993 under the name of Anderson), she describes reform as dynamic movement on a continuum. Placed along the continuum are the indicators of a school in various stages of the change process. This continuum does not suggest that schools abandon historical practices; rather the emphasis on particular skills shifts as a school reforms its practices. For example, decoding skills, such as recognizing letter-sound correspondence, is not abandoned. Instead the emphasis shifts to meaning making, de-emphasizing but not abandoning decoding skills. In a similar manner, the lecture is not completely disregarded; instead practices such as cooperative learning are used more frequently.

Her framework serves well as a means for examining the day-to-day practices of teachers as they work towards the goals of CES and, indirectly, SRA. If at one end of the continuum are those signs of traditional schooling and the other end are indicators of the actualization of each of the common principles, a picture can be sketched that conveys Edison's journey in reform, yielding a portrait of the successes and the challenges remaining to be addressed as Edison moves towards its goals. Furthermore, Parsons' continuum with its shifting emphasis provides a way of stepping back and looking at the full picture of the classroom practices, noting that the shifts may be more complete in certain areas than in others.

Principle 1: Using their minds well. The first CES principle demands that schools are places with an intellectual focus. Within the vocabulary of the Edison teachers and emblazoned on documents is the phrase "use their minds well." This goal to stress academics must be paired with the events in the classroom to move from the philosophical to the actual. A look at a typical lesson in the middle of a unit in A.S.P. will illustrate how Nancy and Anne define "using their minds well" and will suggest obstacles in the reform process.

> *One fall day, half the students began the class in history as usual, the other half in English. Anne opened the history lesson with a "sponge" activity. "I want you to think about accidents. Write about an accident or an illness that you had when you were little." Anne's goal was to connect familiar and personal events with the upcoming content of the lesson, ensuring that students will be able to relate to new information.*
>
> *The students opened their notebooks and began writing. Only the sound of pencils marking the paper and the hum of the class next door could be heard. After a few minutes, she asked them to share what they had written. Hands flew up. She called on Sam. He read about a time when he was little and drank paint thinner. When Sam finished, other hands flew up to read their stories. After three more students had read their journal entries, Anne made the transition into the content of the lesson. "Today we're going to talk about those brave souls who traveled westward." She pointed to the map. "Early in our country's history the majority of the population lived here." She lectured to the class. Most of the class listened even though no one took notes.*
>
> *Anne stopped her lecture, turned dramatically to the students, and asked, "What do you imagine Mrs. Austin was wearing?" Anne wanted to continue drawing the students into the lecture. Again hands flew up.*
>
> *She nodded in affirmation at the guesses and continued. "Let's think about how Austin and Sam Walton are similar and work on a Venn diagram." A common metacognitive strategy, a Venn diagram consists of two intersecting circles. In the*

> *overlapping portions of the circles, students recorded shared characteristics of Austin and Walton. In each of the two areas of the circles not connecting, they listed the unique qualities of Austin on one side and Walton on the other. Since the Venn diagram is used frequently by this class, they were able to quickly complete the diagram.*
>
> *Her story of the westward movement switched to the Flathead Indians and again she dotted the narrative with questions to the class. "Why do you think they're named Flatheads? What do you think happened when the white man came into their lands with diseases they never faced?"*
>
> *Interwoven with the story of the history of the westward movement and the questions were connections to events with which students were familiar. "What happened to Ryan White or others who were first to get horrible diseases?" And again the students eagerly responded. She tied the lesson together by making connections among their childhood illnesses and stories from the start of the class, the Astors, and the illnesses of the Flatheads.*
>
> *She handed out a worksheet, a "retrieval chart" to help students process the information. She explained, "This is for individual accountability, but your group can help you process it. If anyone took notes, be sure to use them or you can refer to your textbook."*

One pattern of a day in Anne's class is clear. She set the students up with a "sponge activity," lectured for ten to fifteen minutes, and moved the students into group work. The question, however, is: are students using their minds well? Are they intellectually engaged in thoughtfulness? The answers to these questions are mixed.

Anne hoped that the structure of her lesson would ensure that students would use their minds well. Because of her belief in connecting the learning to student backgrounds, she frequently interwove the familiar with the new content. Student attention was high during this part of the lesson. Her use of metacognitive strategies was designed to help students learn content. Instead of asking them to memorize a list of facts, she frequently gave them tools such as the retrieval chart, the Venn diagram, and the spider web. These strategies were integral parts of her pedagogy, rivaling goals for mastery of content. When asked what her outcomes were for the westward movement, Anne explained that all the students would be able to use the retrieval chart and the Venn diagram. Anne had shifted her emphasis from facts to metacognitive strategies that could be used in a multiple settings. She had the strategies for accomplishing this shift of goals for content from a traditional to a new system firmly under her control.

Unfortunately, the intentions driving these practices were not materialized in the actions of the students. No student on this particular day nor on subsequent days took notes or used the Venn diagram independently, nor were they asked to do so. Any student who listened could have parroted the information from the lecture to successfully complete the assigned group task. Part of the discrepancy between the goals and the intended outcomes seemed to be in the teacher's perception of strategies. The metacognitive strategies, rather than the knowledge gained through their use, became the goal for much class work. The strategies became the end, rather than a means to an end. Students frequently understood the tools, but they did not connect them to the intellectual goals of the course.

Principle 2: Less is more. The second CES principle recommends that curriculum developers determine the essential qualities of the content under study and focus students on those elements. Rather than attempting an encyclopedic coverage of content, teachers are encouraged to pare down and to keep in mind "less is more." By examining a limited amount of content in depth, students will not only use their minds well but gain basic skills and knowledge.

To accomplish this goal, the use of essential questions is encouraged and clarified in the district curriculum guide:

> Teachers have been organizing instruction around themes, problems, and issues for decades. Too frequently these organizers have been designed so that the learning drifts in unpredictable ways toward unwanted outcomes. One concern when using organizers instead of a scope and sequence approach is that content is removed from the curriculum. The way to avoid this problem when developing an organizer is to create a set of guiding or essential questions.

This curriculum guide indicates that essential questions become the scope and sequence of the organizer. The criteria include:

- the questions should be written so every person in the class can understand them;
- the questions should have no obvious "right" answer;
- the questions should reflect higher order thinking. They should require synthesis, analysis, and evaluative judgment;
- the questions should emphasize concepts while requiring students to use knowledge in developing answers;
- the questions should cause the students' learning to uncover and recover important ideas.

Prominently displayed in the rooms were the essential questions the A.S.P. team had designed for each of the six units studied during the course of the year . The connection between activities and essential questions was not always clear, however. Several examples will illustrate.

Even though students generally enjoyed this course, they did not habitually recognize the essential questions except when assessment time approached. In one interview, the researchers asked a student if he paid attention to the essential questions posted around the room. Candidly he stated, "Well, to be honest, no." Earlier, however, he articulated the teachers' reasons for essential questions: "I guess it sort of helps you, 'cause they make everything connect together." However, essential questions did not provide a way for him to organize his thinking nor did they help him make connections between the daily lessons and the overall picture of the unit. The essential questions appear to be a starting place for beginning a unit, and a clear statement of the focus for how the students will be assessed; however, these questions did not provide the road map for day to day activities, nor did the students see their importance.

In a new unit created this year, the essential question "How do we stop violence in today's society?" did guide curricular choices. Speakers, films, and readings centered on the issues of violence, such as family and date abuse, homicide rates, and victim rights. The assessment task was to develop a five minute presentation which demonstrated that students thoroughly understood the question. Each assessment task required a short summary of the oral report, a map that related to items in the report, and a visual that clarified or illustrated the presentation.

Lisa, a very motivated student, spent many hours after school preparing and rehearsing her presentation. As a result, her work was one of the best ones observed over the three days exhibitions were presented. She earned an A, or 100%, for her work. Despite her effort and her high grade, Lisa's work was surprisingly disappointing:

> I think that violence is extremely the highest thing in America. And it's because of television and movies. Some of the movies that are on television have a lot of violence in them and parents don't pay any attention to what they are watching. And I don't think the laws are strict enough today. Because when you have serial killers that can't stop killing and if they get out they'll keep killing. And they can't do anything about it. They just let them out and they kill again. And drugs and alcohol are another reason for a higher crime rate. I think they need to do something to stop it out on the streets. And I have some rates here: 53% males are in gangs and 34% are females. [She held up a poster illustrating these statistics.] And I have 47.3% that are white and 39.8% that are black that are in gangs. And I think that racism may be another part of violence because parents raise their kids to be racist and not to get along with everybody. And people are getting carried away with hurting other people. And then they see people on television doing it and getting away with it, they think it's okay. I have a map that has per 100,000 in each state that are murdered in 1990. Texas and New York are two of the highest. Kentucky's was 6.2 in 1990 per 100,000. [She held up a map which shows the statistics in various states.]

Because her presentation did not take the full five minutes, the teacher prompted her with questions:

> Teacher: Lisa, you mentioned racism and there's been a lot of information on the media about the amount of racism in police departments because of some cases like the Rodney King case. Do you think racism is a problem in our schools? And if so how would you see us dealing with racism as an issue?
>
> Lisa: I don't see much of it in the schools but schools that do have racism, I don't know. Maybe they need to work on it and try.
>
> Teacher: How do you suggest they work on it?
>
> Lisa: Talking with each other.
>
> Teacher: Do you think we're going to stop the violence in our society with the crime bill that the governor introduced yesterday?

> Lisa: I don't think that will completely stop it. I think it will calm some of it down but not stop it.
>
> Teacher: What aspect of the crime bill do you think is most important?
>
> Lisa: I think the sentencing needs to be changed.
>
> Teacher: What about early parole, where some people only serve one month for every year they're sentenced?
>
> Lisa: If what they did wasn't like harming someone else, yeah.

Several problems are obvious from Lisa's presentation. Nowhere did she directly answer the essential questions: how do we stop violence in today's society? Instead, she attempted to analyze the causes of violence. However, she did this poorly. Warrants were missing; the argument was incoherently threaded together; and her responses to the teacher's questions suggested limited knowledge of her topic. Lisa's work did not reflect the goal of depth as implied by the aphorism "less is more." Rather her work showed the accumulation of surface facts garnered from newspapers and magazine articles without substantial reshaping of those ideas. The robustness of a highly intriguing essential question did not provide enough of a framework for her to grapple with one of the tough issues of contemporary times.

On the other hand, her presentations skills were smooth. She spoke clearly and maintained eye contact with the audience. Her visuals were brightly colored and attractive. The form of the presentation was stronger than the substance of her work.

The task suggests that the teachers conceptualize the curriculum so that the requirements are "shaped by the intellectual and imaginative powers and competencies that students need," as stated in the second common principle. Rather than ask students to list memorized facts, the teachers have designed an essential question that required higher order thinking and had the potential to promote synthesis, analysis, and evaluative judgment. The questions Anne asked Lisa after the presentation were rigorous, requiring sophisticated thought.

An examination of the teacher's efforts without the corresponding student work would lead an observer to believe that this classroom is one in which students do, indeed, use their minds well. The teachers are shaping tasks around rigorous concepts; however, the work that is accepted and rewarded is often shallow and lacking coherency. Missing is attention to a phrase buried in this second common principle: "curricular decisions should be guided by the aim of thorough student mastery and achievement." To ensure that students have mastered essential skills and areas of knowledge, the teachers must pay explicit attention to student work.

At this point, the teachers on the A.S.P. teach are attending to new ways to design curriculum and to assess students, complicated skills of themselves. In the process, they have not yet been vigilant in their assessment of the intellectual fruits of their students' labor.

Principle 3: The school's goals should apply to all students. The third CES principles attacks the familiar practice of homogeneous grouping or tracking with the concomitant practice of "dumbing down" expectations for students in lower tracks. Even before SRA was in place, Edison raised its expectations for all students. All low level classes and general track curricula have been eliminated. Students chose either a "tech prep" or a pre-college program, or a combination of both. Classes are grouped heterogeneously; however, honors credit for accelerated work still exists. Honors credit, replacing advance placement courses, is indicated on students' transcripts, reflecting that the work completed in classes with such designation has met rigorous standards. Rather than only a select few students earning this credit, all students are eligible. Teachers design their own policies and then inform students of the requirements for honors credit.

Unfortunately this leads to an unevenness of implementation. One long standing team, highly respected, is the ninth grade interdisciplinary team. A group of five teachers works with about one hundred students for five hours a day. These teachers plan the students' daily schedules, team teach, and design assessments together. In their planning meeting at the start of the year, they spent considerable time struggling with how to build depth and sophistication into their expectations so that students aren't just doing different or more work for honors credit; instead the discussion focused on the quality of work students produce. In contrast, the A.S.P. teachers regularly list additional work students need to complete along with the regular work to earn honors.

The tension between quantity and quality of work has not been addressed by the school as a whole. However, the opening up of honors credit to all students provides a glimmer of hope to the most surprising students. This was particularly evident one day in A.S.P. Mark, an eleventh grader who sucked his thumb and struggled with his reading, decided he wanted honors credit. While working on the current events assignment, Mark cut out articles with his group. There had been some tension earlier in the hour between Mark and another boy. It continued.

> "Thirty five cents," the other boy read aloud a price in the newspaper. Looking at Mark, he sneered, "That's how much your house payment is. What are you doing? You cut cartoons out only if you want honors credit."
>
> "Yep," Mark responded, "I'm going to get honors credit. I'm not dumb!"
>
> A girl in another group hollered, "You can't even read."
>
> "Going to make honors credit to be one of the smart kids." Mark continued looking at the political cartoons, but eventually stopped when he struggled to understand the meaning.

The opportunity exists for all students to be successful, but some students like Mark need extra support to achieve those goals. Some students have found institutional support for achieving academic goals. After Hours, a program mandated by the state law, allows additional time for students to reach the expectations of the school. This after school program makes it possible for students to repeat any course. After successfully completing the required work, they may raise their original grade one letter grade.

Another way the school provides assistance for students with special needs is the use of the resource teacher. One is assigned to the A.S.P. team. Within A.S.P. are Jimmy and Ronald. Jimmy is blind, and Ronald is autistic. Both students, however, are expected to follow the rules of the classroom. Jimmy's blindness did not excuse him from the class work. He was expected to contribute to class discussions, prepare exhibitions of learning, and complete the required charts. With the help of his resource teacher, friendly students, and a Braille typewriter, Jimmy fully participated.

Ronald, on the other hand, moved from class to class completing token assignments. Each day that class would begin, Anne would hand him a map or a picture to copy and set him on his way to finish the task. At the end of each hour, she would praise his efforts, often displaying his work for all to see. Only occasionally did the resource teacher work with him; however, she was available to advise Anne and Nancy as they worked with him and other students, such as Mark.

Because of the low academic skills of many of the students, Anne and Nancy worked hard at addressing the needs of the students. They are committed to taking the students from where they are and moving them forward. During course instruction, they regularly paraphrased and discussed the reading to help compensate for the poor reading skills of some of their readers. Both tried to push the weaker students by encouraging them to consider college, bringing guest speakers into class who would challenge the students, and taking them on field trips to major events like plays in the city.

One option many Edison teachers have taken advantage of is an alternative grading system. The lowest grade students could earn is a C; otherwise, the grade was an incomplete. For a grade and thereby course credit, students had to complete missing assignments. To implement this policy, the teaching team in A.S.P., which included the resource-teachers as well as Nancy and Anne, divided the students with incompletes, so that each adult was responsible for urging students in her group to complete the missing assignments. They made phone calls home and almost daily reminded the students. If necessary they would tutor the students during advisory or find peers to tutor the reluctant A.S.P. students.

Because of the structure of the school and the clarity of their beliefs, Nancy and Anne have been able to shift their practices so that goals do indeed apply to all students. The learning and physically disabled, the remedial and the gifted student, the apathetic and the engaged students are all expected to meet the course expectations. Policies, such as honors credit and the alternative grading plan, ensure that the beliefs of the teachers are operationalized.

Principle 4: Personalization. The fourth CES principle stresses personalization. The value placed on this principle can be seen from the moment one walks in Edison. The office feels like a home rather than a cold, efficient, depersonalized setting often found in schools. Photos of students are on the office walls. Plaques honoring students sing the accomplishments of students. The one place in the school which is seen by more students and teachers at one time is the cafeteria. There, during the day, students and teachers eat lunch, and weekly, teachers meet after school for staff meetings. On the bulletin board in yellow and purple are the names of students, all seniors. In the center of the board are huge letters spelling out the word YES, standing for You're Exceptional, Seniors.

Other places around the school honor the accomplishments of students. Outside the A.S.P. room are several walls plastered with student work: maps by Matt, a graph by Bill, posters by other students. Everyday during the announcements, students' names are mentioned with praises of their work. This appears to be a school where teachers care and teachers know the students.

Within the A.S.P. concrete signs of personalization are everywhere. The room is far from an antiseptic environment. Along with the dummies lined on top of bookcases and the posters with humorous or serious messages filling the backs of shelves, the walls are covered with student work. The room felt warm and personal. In drawers of her desk, Anne kept cough drops, tissue, and aspirin where she directed students who came in with a sniffle. Students know they are cared for. As one student said, "If people ain't learning here, it's their own fault. The teachers will help. All you got to do is ask them." One day a student showed off a note Anne had given her. On pink paper, folded like a greeting card, the words "I love teaching" were written inside a heart. On the inside, Anne thanked Lisa for the completion of a task above and beyond the call of duty.

Maxine modeled personalization. Not only did she make it a regular practice to know the students around school, but she also knew her teachers' strengths and weaknesses. When a teacher did a good job, she searched for honors so that the teacher would be recognized. To ensure that ideas are validated and spirit of innovation continues, she provided release days for teachers to write grant proposals, and when visitors walk the halls of Edison, she sang her teachers' praises.

One formal means of institutionalizing personalization is Advisory, a daily 25 minute period in which students meet with their advisor for personal attention and tutoring. Each advisor has a specific number of passes she may distribute to her advisees if they need to meet with another teacher for tutoring or to make up a test. Those students who stay in Advisory either socialize with their peers or participate in activities designed for affective needs.

Anne's advisory is an exception to the normal advisory group. A few years ago Anne became concerned about the number of teen parents at Edison and particularly concerned with the lack of their parenting skills. To address this need, she proposed an advisory just for teen parents. Soon her group was very full, yet more students were frequently added to her group. In her advisory are not only teen mothers, but also teen fathers. Unlike other advisories, Anne developed curriculum. One time she taught the students about fire safety. Another day she taught them the importance of reading to their children, providing children's literature they could check out. Several times during the year, she brought in a camera loaded with film and let each student take the camera home to shoot three photos of their children. She then encouraged the students to create a photo album. Anne's advisory makes a difference in the students' lives. Cecelia, one of Anne's advisees, emerged as a successful student even with her two year old daughter at home and made plans to go to college to become a registered nurse.

The connection between curriculum and the lives of the students can be seen by grants won by the school. In Creative Problem Solving, a class proposed, designed, and taught by Anne, students set out to study the school's high absentee rate. The students conducted a large scale study, surveyed the student body, investigated absentee records, and interviewed students. Their results revealed that a high percentage of missing days was due to medical problems. Based on these results, a grant proposal was written for a health center on campus.

This same class was the recipient of another grant. Along with two other schools throughout the state, these students researched the problem of alcohol in their community and proposed solutions to the problem. The impact of personalizing the curriculum could be seen one day in this class. It was early in the year before a bond of trust had been established in the class. At the beginning of the class period, students were either politely watching the teacher or doodling on paper. The atmosphere of the room changed though when Anne asked the question about the number of liquor stores in their neighborhoods. After Anne mentioned that there were none in her neighborhood, two black students from a low economic neighborhood began counting how many were close to their home. One blurted out, "I bet you'll find more in our neighborhood than anywhere else!" The students selected specific blocks for the count with promises that in a couple of days they would bring in the results of their survey. When the class talk was on impersonal issues, the students appeared to be politely disengaged, but as the discussion moved into closer territory—their own neighborhoods—their interest perked up.

As the teachers design curriculum they keep the students in mind. Recognizing that many are visual learners, they designed activities that include a visual element: maps, storybooks, video excerpts, and the use of costumes. Frequently integrated into the lessons themselves are teacher-made visual aides. Other teaching practices reflect insights into how these students best learn—through drama and stories. Anne's practice of having students dress in costume and act out moments in history is an example.

The influence of personalization is recognized by students. Bill, in particular, expressed his need for encouragement:

> Bill: ... if you had a one to one teaching thing then you would have a lot of all the other encouragement and, you'd have a lot of push from the teacher to get you to do things.
>
> I: Do you feel like you get pushed and encouragement here?
>
> Bill: Yeah.
>
> I: What are some ways you get pushed and encouraged?
>
> Bill: They tell you every day, like this week, to work on a project. They would push you and everyday they would keep reminding: "All right, let's get to work. I want to see your work. Let's go." And that's where they would push you on, and they would just keep doing that everyday and then and encourage you, "Oh good job. That's a good map." People would go, "How do you like my map?" and she'd encourage them and say, "It was a good map."

Personalization is a value that grows from CES, not from SRA. However, it does have implications for the state mandates. The seriousness with which personalization is taken can be seen in Anne's explanation of Edison's poor showing on last year's SRA assessment. When students took the test, they were in the cafeteria with teacher monitors who did not know the individual students. As a result, teachers couldn't add that personal touch of nudging students to stay on task, to complete problems, or to take the work more seriously. Instead it was like "riding herd on a neighbor's herd of cattle." The investment from the teachers was not what it should have been, nor did the students respond to a stranger's call to orderly seriousness.

The value of personalization is operationalized at Edison by those teachers who have been able to shift their roles as teachers. No longer just the academic expert, teachers have learned to assume the role of the counselor and gain expertise in problems plaguing contemporary teenagers.

Principle 5: Student-as-worker. The fifth CES principles speaks directly to a shift in roles for both teacher and student: the student as worker and the teacher as coach. Anne explained that the metaphor "student as worker" refers to the student's role in the learning process. "We don't want classrooms full of passive learners; instead we want our kids to be active in their learning. An active learner processes information and manipulates it, creating a pattern, for example. Students show they know the content and that they can use it. One of the ways we get the students to function as workers is through higher order thinking skills. Students predict, compare or contrast, or tell why a turning point is significant. Our role is different, too. We facilitate, not disseminate. Our goal is to nurture classrooms where people think." This goal arises not only from CES and the teachers' beliefs, but also from SRA. However, a problem emerges in the implementation of this principle.

Student as worker demands that the spotlight shines on the students, rather than the teacher. Kohn (1993) suggests that students take an active role in all aspects of learning, including the setting of goals, designing and completing projects, and assessing the quality of their work. They become the stars of the classroom. This shift of emphasis is still in process in Nancy and Anne's classrooms. For example, the typical organization of a lesson in Anne's classes undermined this goal. She designed the sponge activities; she masterfully reeled students into the lecture through captivating special effects and held students' attention through intriguing stories.

Even though the teachers orchestrated most of the daily lessons, they intended for their students to become engaged with their learning. However, many times students disengaged from the tasks at hand. This became most obvious when expectations were raised. For some students, not understanding the purpose of a requirement led to resistance. Bill, for example, only exerted minimal effort in the creation of the SRA mandated portfolio, claiming it "is just a lot of extra work." He suspected that the purpose was to help him get into college, but he wasn't sure.

In December, Anne and Nancy began working toward the school-wide goal to increase the quality of student writing by encouraging fluency. Too many students on last year's assessment wrote short, undeveloped responses. Since the short answer section of the test was one of the weaknesses of Edison students, a school-wide commitment was made to address this problem. Anne and Nancy began requiring students to write more extensive responses for their frequent journal entries. Students resisted this change in expectations. For example, when Anne introduced the unit on violence, she asked the students to respond to a sponge question: What childhood story, TV program, or movie frightened you as a child? Her requirement was that students "Try to write at least five sentences." A few moaned loudly. Despite their very frequent writing—almost daily in Anne's class—the demand to write five sentences surprised many of them.

This was the same response next hour when Nancy asked students to respond to their reading by writing a full page response. "Stupid!" one girl complained loudly enough for Nancy to hear. "Can we skip a line?" When Nancy refused to be hooked into a confrontation, the girl began to write, but quickly stopped. Ripping the paper out of her notebook, she declared, "That's all I can think of!"

Other students tended to resist engaging in the daily and familiar tasks. However, when assessment time rolled around and the grade was a large portion of the final grade, students became invested in at least producing work which would hold up to the unspoken criteria of the class. They completed the tasks and worked on creating attractive visuals; however, few of the students seemed ready "to teach themselves," as asserted in this principle.

Even though the goal was to move students into active meaning makers of their knowledge, the teachers frequently encountered resistance. The students were often bored by the work and did not want to invest the time demanded of the teachers to produce the required work.

Principle 6: Exhibitions -- Assessment. The sixth CES principle addresses graduation by means other than the traditional Carnegie units. However, many CES schools have generalized this principle so that it applies to assessment practices. The shift in assessment practices is a movement from "objective" tests to open-ended assessments in which students demonstrate their understanding of the course content (Parsons, 1995). In fact, it's during the days prior to assessments when the spotlight shifted focus from the teachers to the students.

> *One early January morning, the researchers arrived at school before the official starting time. Students slowly drifted in and quickly began to work even though the class had not begun. When asked about this anomaly, a student whispered an explanation, "It's because we're doing finals and we have to get our presentations ready." Their task was to select one of the essential questions from the semester and prepare a five minute presentation. The presentation was to include a visual, a map, and research.*
>
> *On this first day of assessments, some students were still putting their presentations together. In the work area out of Anne's immediate teaching area,*

two students traced the map of the United States from an image on the opaque projector. Anne wandered over to Mark and noticed his graph.

"That's wonderful! You ought to make it a little bigger and color it in. I really am impressed with your graph!" He smiled and walked over to the work area where the students were tracing their maps. Finally, another student finished her work at the opaque projector and began tracing his map. In all areas of the room students were bustling about completing their projects. One student was on the phone calling the rape resource center for needed statistics. A few students sat at their desks compiling notes, and a couple worked on the computers. Next door Nancy reminded her students, "What I want to do is go over a few things. I want to make sure I've covered everything. Remember there are four parts to this task: a five minute presentation ... " Students continued working, calling her over for additional help and rushing to finish before advisory interrupted their classes.

The role of the teachers was quite clear at this point. They functioned as coaches, nudging students forward, praising good work, and offering suggestions that would improve student projects. The role of the students was also clear. They were in charge of their learning, moving into areas of the room in order to take advantage of the equipment which would help them produce their presentations, rifling through resources in the room, and initiating the phone calls needed for last-minute statistics. Few students needed to be coaxed into action. The stakes were high since semester grades depended upon the successful completion of the semester assessment.

This expectation for students to perform well on assessments was not just limited to this class. During Advisory, Maxine's voice boomed over the intercom: "Today and tomorrow are designated as end of semester test days. In whatever form this takes, everyone should be honoring the intent of SRA, which is to have students demonstrate knowledge. For that purpose we're going to work hard to limit all interruptions of class time today and tomorrow."

After Advisory students returned to the class. Jody asked if she could present her exhibition. Anne nodded yes, and Jody moved to the center of the room, adjusted the overhead projector, and began. During the introduction, Ronald, the autistic student, began making distracting noises. Matt moved over to Ronald and shushed him quiet. At this point, the students had assumed the leadership role not only for their own learning but for the smooth operation of the class during an important event, the presentation of an assessment.

When finished, Anne asked, "What do you think about child molesters and early parole?"

"I don't think it's a good idea."

"Do you know the success rate of parolees?" Anne probed.

"No."

"Me either, but let me tell you about a story I read in the paper last week." After recounting the newspaper article, she asked, "Should the community be protected? Should we show his face on TV? Do you think we should let him return to the society?"

Jody responded abruptly and strongly, "Don't let him out!"

Anne looked at the class, "Any questions?"

When no one asked a question, Jody quietly returned to her seat.

During the assessment it was clear that students were indeed taking charge of their learning. They selected the question on which to focus; they designed their presentations within the structures handed them; and they initiated the presentations themselves.

The teachers continued to coach afterwards, but in an interesting and confusing manner, similar to questions asked after other presentations. The questions were intended to probe the students' insights, yet any student response seemed to be acceptable. Even though one of the goals of the assessments, according to Nancy, was to make the students critical thinkers, none of the students were required to offer proof for positions, make predictions based on evidence from the past, or integrate contemporary knowledge with historical events. Students were telling knowledge rather than showing how they constructed new insights. Responses were meager, often deficient in sound content. Student reasoning was accepted as if an opinion of any sort were better than no opinion.

Assessments, as well as projects, were often engaging yet problematic. Students connected to the fun of the assignment, but the intellectual effort put forth to produce the exhibitions varied from student to student. In interviews with students about their exhibitions, their comments provided insight into these problems inherent with the exhibitions. Lisa, for example, stressed how hard she worked:

> Lisa: And I think I learned. I worked hard on it but I think I could have worked a little bit harder on it, made it better. I could find like the rapes I needed. I couldn't find an up to date on that so I had to use 1990 which I know has raised a lot since then.

However, she realized that her classmates did not work this hard, most completing the assignment during class time. In contrast to Lisa, Matt admitted that he did not invest much original thought or serious effort into his work:

> I: Tell me what you can about how your exhibition went: how you went about it getting it ready, what you learned from it, and what you thought about it.

> Matt: Actually what I knew is pretty much what I learned for the past seventeen years. So really I just took the information that I had, plus some information that I got from books, the history book that we got ... And that's how I got my information. And pretty much I didn't really learn anything new. It was pretty much all the same.
>
> I: Did it firm up any beliefs or anything?
>
> Matt: No it just, whenever I think of it, it's just the same.
>
> I: Do you think there's any value doing the exhibitions like that?
>
> Matt: Yeah, I guess it gives me the chance to focus on one subject, not about 20 different subjects at one time for one class. And it's easier for me to learn how to do that. And it's also helping me to learn how to speak in public.

In his description of his process to complete the assessment, Matt revealed the importance of the quality of the production of the project. The surface features of the map, an activity in which he excels and therefore values, were more important for him than the knowledge that the map was intended to build.

> Matt: We had actually four periods to do this assessment and the first two I didn't do anything. I just wrote down a few things and that night I went home and I just, I was talking to one of my friends on the phone and I hung up with her, I just took my paper and pencil and I just started writing. And then the next day I just, actually I started drawing here. I drew a map and then I had to go to a basketball game. And when I got home I just started drawing some more and I just blanked everything out.

He explained how this project was different from the work he had done in his past:

> Matt: So I just take the information that I've used before and I just write it down and I just more or less use the same report that I had in sixth grade ... I more or less slice it. I'm putting in different words.

Much of his work is what he has done before: "practically the same as what I already did."

Another student who returned to work she had done in the past was Marie, but she worked with the assignment in order to create something new, something more reflective of who she is as a junior in high school. For the past few years, Marie kept all of her school work in her rather large filing cabinet. Instead of just "slicing together a few words," Marie built from her earlier work. Unlike Matt, Marie enjoyed learning, taking pride in uniqueness and quality of thought. Matt, on the other hand, was invested in his artwork. Other products of his learning are only for the grade, so any means of achieving this goal will satisfy his needs.

The definition of hard work varied for each of these students. For Lisa "effort is hard work, like putting your mind to what you're doing, not on other things. What you're thinking about is what you're trying to do." For Marie, originality resulted from hard work. Other students seemed to avoid working hard out of class. This avoidance was reflected in the content used to build their final assessment. Many, such as Bill, mostly used content already studied during the semester. When asked how much of his content was based on new information, Bill admitted that approximately 25% was new, the rest straight from work already studied. Reversing the statistics, Lisa thought that 75% of her content was based on original research that built from the 25% of course content used in her presentation.

The semester assessments spotlight a contradiction which runs throughout the school. In their all day planning meeting at the beginning of the year, the ninth grade team of teachers designed a strategy to ensure students would be challenged throughout the year. The time requirement would gradually become more rigorous. The requirement for early exhibitions was 15 minutes while by the end of the year, the exhibitions would last 45 minutes to an hour. Unlike A.S.P., the ninth grade exhibitions were group projects. With each exhibition, the students would present their exhibitions several times, each time to a different audience. With each presentation, they functioned in a different role. For example, if a student in one presentation were the panel moderator, the next time she might present the findings of the research or explain the visual. In contrast to these expectations, all eleventh graders at Edison prepare presentations lasting five minutes, a time many of the students worry about. Because the interdisciplinary teaching teams rarely interact with each other, these differing expectations do not tend to surface.

Assessments, as well as projects, often were engaging—even though the effort students put into them was uneven. Students focused on what they saw the teachers valuing, the sophistication of the performance. The depth of the knowledge was not the issue, nor was the quality of the student work. As seen through the grading system, the teachers wanted work completed regardless of the quality of the work. At issue was completion of tasks rather than thoughtful engagement with intellectual activities. Frequently, grades were based on the surface qualities of the presentation, such as attractive visuals and adequate volume, rather than the depth of thought of the research. What was missing were standards describing the expected levels of performance. What was emphasized, instead of content and depth of knowledge, was the quality of the presentations. Did the students speak clearly? Were their maps and visuals appealing? Did the students make eye contact?

Goals articulated by the teachers, such as critical thinking and integration of current events with historical settings, did not face the tests of reality. The work students produced reflected their concerns with how they would present the information; the questions students answered after the presentations did not provoke deeper insights into what students actually knew, nor did the questions challenge the students to work harder in the future. The questions helped fill the required time slot and highlighted knowledge teachers had presented in various lessons, rather than knowledge students had constructed either in preparation for the assessment or during the unit of study. Since the expectations for quality of work were not clear, students interpreted the assessment tasks as reshaping learning from earlier lessons rather than creating tasks which emphasized reasoning and clarified complex problems.

Graduation by exhibition. In response to a request by the State Board of Elementary and Secondary Education, the State Department of Education appointed a group of educators to the Task Force on Restructuring High School. Their charge was to propose minimum requirements for high school graduation based on SRA's six learning goals and 75 learner outcomes. After nearly a year of working on this project and 28 public hearings, the Task Force recommended that in the year 2001, all high school diplomas will be based on performances and demonstrations, rather than mere completion of a certain number of Carnegie units. The proposal contains the following components:

- individual graduation plan: each student will develop an individual graduation plan that documents an academic program of study for achieving the learning goals and outcomes;
- integrated academic portfolio: each student will develop and maintain a portfolio which will be presented to either a teacher or a panel for approval;
- student-initiated culminating project and panel presentation: each student will design a significant culminating project, including a written document with evidence of research and a presentation of the project to a panel for approval;
- school sponsored activities: each student must participate in at least one school-sponsored activity during the time at high school;
- service learning: each student will participate in two meaningful activities that benefit the school, the community, or the workplace.

In addition, students must successfully complete the assessments and have their graduation work verified by a school official. Nancy and Anne endorse this graduate plan even though it does not directly impact their current teaching situation at this time.

Principle 7: Unanxious expectation and decency. Teachers, perhaps more so than students, feel the "unanxious expectation." Although much is demanded of them from their time to their self-direction, they seem to feel safe at Edison and trusted. Even knowing that Edison stands in danger of becoming a "school in crisis," Nancy and Anne do not fear the threat of probation or loss of salary as stated in the law. Maxine has diffused the fears which could be so invasive to a staff.

The incentives "appropriate to the school's particular students and teachers" can only be inferred. Teachers are not paid bonuses for their ideas and innovations. However, they are praised and provided release time in order to receive additional training, to meet, and to work on school related projects. Because of the involvement with CES, many of the teachers spend time at conventions, such as the Fall Forum, or at other CES activities, all paid for by the school. In addition, Maxine frequently publicly acknowledged the hard work of her teachers and encouraged media to visit. These efforts have paid off. One team of teachers was filmed by

Tom Brokaw, another team became the basis of a CES training videotape, and other teachers often find their pictures in local newspapers.

Some students are offered similar incentives. Student CES reporters, for example, are trusted to work with the computers at any time they wish. They know where the keys are kept to unlock the cupboards in order to use the computers. Anne is particularly good at finding special treats for her students. When a wealthy community member donated tickets to a major dance production, Anne selected students who had performed well in class to attend. When many of those students were unable to go, she distributed the complimentary tickets to any interested students.

A common thread in all the student interviews was the belief that the teachers genuinely liked the students. Marie summed up the feeling, "If students don't learn, they better not blame the teachers. They're there for you."

Principle 8: Generalists first and specialists second. The staff at Edison are not just teachers. Instead their responsibilities address multiple obligations. A quick look at Nancy's duties will illustrate. Along with teaching her five classes, she worked with her advisees who she counseled about personal, academic, and social problems. After school she either rushed to a committee meeting or a district meeting. Occasionally she left school for several days on end in order to receive further training at Brown University with CES. Because of her training, she was a leader of her peers, frequently conducting staff development courses. Several times a year she mentored either a student teacher or a practicum college student. All these commitments left her exhausted and excited at the same time. What sustained her was a belief that her work would make a difference in students' lives. Nancy was not different from many of the other teachers at Edison. They too are advisors, committee members, writers of curriculum and grants, students, and teachers.

Principle 9: Eighty to one. The goal of eighty students per teacher is far from realized. At the beginning of the school year, one cause for stress was the sheer number of students Nancy and Anne were expected to teach. Even though the morning class was manageable, the afternoon class had more students than they had chairs. Over 70 students filled the two rooms, creating a daily teaching load of over 150 students. If the advisory students were taken into account, the number of students each teacher taught ran over 170 a day. By the middle of the year, though, this number was greatly reduced. Students in the afternoon class were transferred to other classes and several left school for a variety of reasons.

Time is a crucial element in an interdisciplinary setting. Teachers need time to plan, to discuss students, and to assess learning. At the end of the previous school year, teachers on teams had been promised a lighter teaching load than other teachers, only four classes rather than the usual five. However, this was a promise the administration was unable to keep. The realities of the budget surfaced, and the promise was reneged. At the beginning of the current school year, some teachers were still angry about the unkept promise. However, these concerns were never voiced by Anne or Nancy. Their hour together right after A.S.P. and their time at the end of the school day was certainly not enough time for them to plan and to assess. Many nights were spent on the telephone discussing upcoming events.

III. THE CONTEXT OF CHANGE

For meaningful, lasting change, six elements need to move forward on the continuum: goals for student learning, content, teacher and student roles, student work, teacher learning, and public and political support (Parsons, 1995). Because schools are part of a complex system, each of these elements must be considered contextually. Formal declarations of the state might shape conversations about classroom practice, but the intricacies of the culture of the setting invoke their reality (McNeil, 1986). Within each setting, policies, teacher skills, and student willingness to participate in the norms of the school interact to form the day-to-day realities. An analysis of school reform is incomplete unless the elements of change are seen through the context of the setting. In this section a more global picture of Edison will be presented, one which still incorporates life of the classroom but notes the outside influences that shape classroom practice.

Goals for Student Learning

If the official documents formed the only basis for analysis, clearly Edison would be a school that is reformed. The district's curriculum guide, reflecting the official stance of the state, reads: "The centerpiece of [this] ... education reform effort is its vision of what students should know and be able to do as a result of their school experience. Every aspect of the reform movement is designed to promote student attainment of these goals and to measure our success in helping them to do so."

The goals for student learning are shaped by the 75 outcomes mandated by SRA. Edison is in a unique situation in that these mandated goals for student learning match the culture of the school. For instance, Nancy and Anne have moved a long way from focusing on discreet, decontextualized skills. Their goals for learning aim toward student control of metacognitive strategies, insight into the complexity of contemporary issues, and attainment of skills for the workplace. These goals are in harmony with SRA.

Since Edison is in concert with the goals of SRA, the state assessment program provides a valued means to determine the school's success at achieving its goals for student learning. District documents and the state's reform effort provide a foundation for Edison's achieving these goals; furthermore, its commitment to the CES principles grounds this work. Because of the meshing of the state and school's goals, the results of the annual assessment are particularly powerful. Teachers examine the results of the tests and design strategies to ensure their students will perform even better in the upcoming year.

If the rumors around the school are accurate, Edison's trust in the assessment program differs from other schools in the district that do not find their beliefs reflected in SRA. These rumors assert that at a neighboring high school attendance figures are adjusted before the state assessment so that students with attendance problems are expelled; therefore, their expected low scores would not impact the school's threshold score. Another school is suspected of releasing a teacher from teaching duties before portfolios are assessed. During the release time, the teacher's task is to edit the writing in the student portfolios. Shocked by these rumors, Anne and Nancy are thankful for Maxine's leadership.

Even though Nancy and Anne are fervent supporters of SRA and adapt their learning goals to the deficiencies in the tests, their goals are often mediated by student resistance. Since many of the students see the goals as meaningless demands of the school system, they often exert perfunctory effort or loudly vocalize their discontent. One result of this resistance is that Anne and Nancy's goals for student learning were waylaid. Instead of focusing on both what students should know and be able to do, they focused on the "doing." Often their goals translated into students completing tasks rather than mastering concepts.

The goals for student learning are shaped by multiple forces. The official statement by the state and the district is echoed by the teachers who hold faith in those goals. Yet the implementation of those goals is mediated by student response, resulting in a reshaping of the official stance.

Content

The curriculum guide describes the curriculum: "Traditionally, the focus of a unit has been determined through a content-centered approach; but, an authentic, meaningful curriculum addresses relevant issues of self and society with the content serving as a unifying thread." The curriculum guide urges teachers to integrate curriculum. This suggestion is tacitly echoed in CES literature, often an outcome of implementing the second principle, less is more (Wasley, 1994).

Rather than limited to traditional content in history and literature classes, Nancy and Anne trusted that the state's effort at reform encouraged them to wander from traditional topics in school. The unit on violence, for example, was not a historical study of an era. Instead this unit explored the violence in the world these students faced day in and day out. Through an examination of current events in local newspapers, popular magazines, and television shows, the students learned about abuse and crime rates. The reading and the writing in the literature classroom was not dictated by the literature canon; instead, students read and wrote about current events. Unlike other units, the students were highly engaged during this unit, many of them mentioning this unit as their favorite of the year.

The content of the curriculum reflects movement on Parsons' continuum. The emphasis of the content is on concepts, metacognitive strategies, and meaningfulness rather than on the accumulation of facts. Content has changed and the goals have changed. Teachers have updated the curriculum, making it more relevant to the lives of their students. Support from the district and the state promote these changes.

Teacher Role

SRA and CES urge a shift in a teacher's role from one who dispenses knowledge to one who facilitates and coaches. This shift is one both Nancy and Anne embrace, albeit a difficult role switch. An analysis of the role of the teacher in the A.S.P. program reveals the many hats these teachers wear. On occasion, they were dispensers of knowledge; other times, they were entertainers, coaches, and facilitators. Even though Nancy and Anne's aims were shared -- to become coaches or facilitators of learning, their most common role leaned more toward director of activities. As directors of class activities, they orchestrated the structure of the class, set the students' goals, and determined the class content. Yet when students were in groups, Nancy and Anne became facilitators, guiding group discussions, asking probing questions, and halting unnecessary conversation.

When students were working on exhibitions, the coaching role was most fine-tuned. Both teachers stepped back from the dispenser of knowledge and director of activities roles to assume the role of the coach. As coaches, they nudged students forward, encouraged them by praising the work in progress, and supplied many of the materials needed to complete the task at hand.

Embedded in the system are the keys for Edison's continuing journey into reform. The district's curriculum framework offers insight into the next steps as the teachers shift between paradigms: "Student-centered instruction addresses the personal, social, cultural, and global concerns of the students and focuses on outcomes rather than input." In many instructional situations the teachers focused on their input. Particularly while learning new strategies, they attended to their emerging skills. During assessment times, however, their new roles were clearly demarcated. The purpose of the assessment activities was to determine the outcome of the unit work, and the task demanded that the role of the teachers shift from disseminator to coach. As their insight ripens and their skill in using new strategies becomes well honed, the teachers may more easily be able to complete their transition into coaches.

At Edison, support exists for teachers to learn the role of the coach. McLaughlin (1993) has noted that cohesive, highly collegial staffs, such as at Edison, are ones in which teachers feel a high level of support for growth and innovation. Since learning for both teachers and students requires risk Taking, a sense of trust must exist in the school culture. At Edison, Maxine encourages teachers to take risks, especially as they develop new roles. Aware of the complexity of teachers changing roles, Maxine provides opportunities for teachers to learn new skills. Her style of leadership promotes a culture of growth and risk taking for both teachers and students.

Student Role

Just as teachers' roles shift as new systems emerge, so must student roles undergo a change. Nancy and Anne recognize this need and promote the new roles. One of their goals is for students to become self-directed; however, often their management practices obstructed the implementation of this goal, as noted earlier. Signs of a shift in student roles exist as both Anne and Nancy are learning new ways to involve students. This shift is facilitated by their affiliation with CES. At the start of the school year, they selected a pair of students to be CES reporters whose jobs were to write occasional reports about their view of life in a CES classroom. These two students would quietly slip out of their desks and move to the computers whenever their class work was completed. Without their teachers' permission, they would write the stories and, without the teachers' stamp of approval, they would send off their work through on-line services. Many times after class was over, the two students would return to the computers and continue their writing. They were engaged workers, students working hard on a project they cared about.

This was not the only time during the year that Nancy and Anne involved students in situations in which they had power to control the direction of their academic lives. Because of ideas gathered at a conference, Anne invited several students to join her in planning the violence unit. The students met with Anne to discuss what they wanted to learn and suggested how they should study violence. One reason students considered this unit successful was because of their input. Nancy and Anne also commented on the success of the unit and noted a change in student behavior -- students were highly engaged in the work.

Both situations confirm Kohn's assertion (1993) that the role of students must change so that they have control over what they are doing. But to change the roles of students, the role of teachers too must change. Teachers have to learn to relinquish control and bring students into the decision-making process. Without a voice in the direction of their life at school, the chances for commitment to hard work are minimized. Again shifting the spotlight of attention to students might begin setting the stage for this new role. Through their connection with CES and other professional activities, the spotlight is moving.

Student Work

It is in this area that the challenges ahead become most clear. The work that students are asked to do reflects the goals for student learning, yet the work that the teachers accepted and praised highly did not support the goals. The system has provided opportunities for the teachers to address this discrepancy. For instance, at the start of the year, the state Department of Education sent each school multiple copies of posters outlining the performance standards for the writing portfolio. These posters with an illustrated rubric lined the walls in the A.S.P. rooms, yet students seemed oblivious to the posters, and the teachers rarely referred to them.

Particularly troublesome was the issue of effort. Students tended to equate the amount of effort invested in a task with the grade they deserved. Understanding of standards appeared to be non-existent. Instead, students frequently talked about the time they put into a project. If they received a high grade with little time or effort put forth, they were proud of "pulling one over" on the teacher. All students interviewed, however, did receive a high grade if they invested time and effort into the task regardless of the quality of the end product and regardless of the work meeting the criteria outlined on the poster rubrics.

Two issues seem to stand in the way of matching the goals for student learning and the quality of work: the teachers' perceptions of the student needs and time. Since so many of the students at Edison are at-risk of dropping out of school, the teachers are proud of the decrease in the drop out rate since they began working within the reform milieu. As a result, one of their chief goals is to design work that engages students. As Nancy explained, "With 70% of our students at-risk, I want to give them assignments that work." When asked what she means by "assignments that work," she explained that the assignments should be intriguing enough that students are pulled into the task. Little teacher direction and a minimum of teacher prodding would be needed for the students to begin working on the task. The difference between the goals for student learning and student work is that informal, implicit goals drive the decisions the teachers make. Hoping to engage the students through the intriguing assignments, the teachers consider an assignment successful when they can coach and not become an "enforcer." At times this hope undercuts the goals for learning.

The second issue undermining the goals for student learning is time. To carefully attend to student work, teachers need the time to study the work in order to assess how the work at hand supports the goal of using the minds well. Time is a rare commodity in schools. Teams of teachers need time to meet for planning, and students often unexpectedly show up for help. Because Nancy and Anne, like other teachers at Edison, are part of many committees and involved in a variety of professional activities, their time at school is devoured by meeting deadlines. Partly because of their commitment to teacher as generalist, rarely is there a day when the two of them could sit down and thoughtfully study the work their students had turned in; however, without this careful perusal of the work, the students will still be in a system that requires little of them. The in-depth study of student work essential to ensure that students are using their minds well is cobbled by the pressures of the professional life and the implicit goal of engaging students with work that is first and foremost intriguing regardless of the intellectual rigor.

Assessment

Perhaps in no other area is the reform effort more clearly felt than in assessment. The curriculum guide suggests seven assessment practices, none of which follow the traditional assessment models:

- anecdotal records
- checklists
- interviewing students
- observations
- performance events
- exhibitions/portfolios;
- self-assessment techniques.

Additionally, teachers are encouraged to use culminating performances: "The culminating performance should demand intense work and preparation on the part of students. It should require persistence, organization, and inquiry skills associated with the state's learning goals." The guidelines for developing a culminating performance suggest tasks which "prompt students to stretch their minds and make connections. It should put knowledge in a sensible context which supports the value of content learned. It should assess several unit outcomes."

In A.S.P. rarely did students complete traditional paper and pencil tests. Instead, the primary method of assessing student learning was the use of exhibitions of learning or the culminating performance. Students focused on the essential question, proposed an answer, and presented their findings to the class. The assessments were intended to be complex, requiring the use of research, visuals, and fine-tuned presentation skills. The breakdown of the assessment system, though, is similar to the breakdown in the student work. The quality of the work was not articulated. Even though the walls were filled with SRA posters describing the various levels of performance, the teachers did not incorporate those levels into their expectations. Since the unit outcomes were listed as activities rather than intellectual processes, the expectations for students were not aligned with SRA.

The grading policy reflected these problems. Rubrics tended to be checklists rather than descriptors of performance levels. This listing of activities was easily interpreted by students as a completion of tasks rather than mastery of an outcome. Students were not asked to redo work of low quality. Instead if they completed the work, their grade implied they had successfully completed the task.

At this time, the teachers are still in the process of learning a new system. They have integrated the elements of the process -- the rubrics and performance tasks. Missing at this point is attention to the meaning behind the changes.

Teacher Learning

According to Prestine and Bowen (1993) teacher learning is pivotal to a school's successful efforts at implementing reform. Deeply entrenched in educational practices are beliefs that undermine efforts at reform (Sarason, 1990). Aware of this need to challenge beliefs and educate the staff in new ways of doing school, the district, the state, and the school have actively promoted teacher learning. Staff development activities in the building, classes at Peterson Academy, workshops prepared by the Department of Curriculum, documents from the state Department of Education, and summer training with CES are designed to help teachers meet the goal of being scholars in general education. In this category, Edison is far along on the reform journey.

The district has created a system for teacher learning that supports a pattern of growth and collaboration. Through the requirement that teachers earn 24 hours of staff development annually, the district demands that teacher continue growing. However, some of the help is supportive of SRA's intent while at times the message and the medium contradict. This is particularly important to keep in mind when one remembers the prescribed role of the Department of Curriculum: to help teachers internalize the curriculum framework.

Just as Nancy's and Anne's practices were not fully aligned with SRA, neither were the practices of the district's staff developers from the Department of Curriculum. This misalignment could be seen in two after school inservices. Each month teachers were trained on one aspect of SRA. At one inservice, a well-respected presenter, who directed the portfolio project for GCSD, was the trainer. She began her by praising Edison as "a premier school" since students had kept portfolios in all subjects long before SRA's mandate. "The eyes of the district will be on you," she said. From this praise, she moved on to a 45-minute lecture about the design of open-ended questions, often referring to notes on her transparencies. During her lecture, teachers dosed, quietly chatted with each other, and graded papers, while a few took notes on her lecture.

An irony emerged. With a reform that mandates active learning, the presentation mode of this highly respected staff developer was the lecture rather than one modeling active learning. The next day a similar pattern emerged. This time, Joy Green, also from the district's staff development center, introduced the state's curriculum framework. Again her primary mode of presentation was the lecture.

Teacher learning is encouraged by the state through innovative grants which is how A.S.P. received its initial push. Maxine recognized the need for money in a school in the process of reform. "We need massive infusing of money. We need summer time for massive infusion of this. We need summers of learning and practice opportunities for kids... The real challenge is to link it up with teacher training and innovative design. We did that last summer. A local trainer worked with the teachers in the afternoons and then they put the seminars into practices in After Hours. The whole summer was one massive Socratic seminar. Now many teachers use it in their classrooms."

Teacher learning is not restricted to formal workshops and inservices. Nancy and Anne, as well as other teachers, often talked about articles they had read or workshops one or the other had attended. During planning sessions and on trips to school functions, they discussed new ideas and challenged old practices. Thoughts triggered by a CES workshop were discussed in these informal settings and frequently worked into their classrooms. As the teachers learned new ideas and strategies, they were eager to add them to their "bag of tricks." These informal learning groups created a professional community that furthered the goal for teachers to continue growing, innovating, and questioning (McLaughlin, 1993).

However, the problem remained that the teachers were learning new strategies, but students seemed to be impacted only minimally. As a result, many of the new practices transformed the surface of the classroom, not the substance of the student learning. Wasley's work (1994) on teacher change in CES schools provides insight into this problem. Wasley noted changes that teachers in her eight case studies made: focusing units on problems and questions, moving away from textbooks as main teaching tools, linking curriculum and assessment. All these are changes Nancy and Anne have quite effectively made. The final change Wasley noted was the shift from coverage to in-depth learning. Nancy and Anne have yet to take this next step, but the chances are heightened that they will be able to take this step because of the culture of the school.

Public and Political Support

At Edison parents seem to generally support the reform movement at their school. Much of the support must be credited to Maxine. When Edison first explored CES ideas, a small group of parents voiced their concerns. Maxine invited them into the school on many occasions and listened to their worries. Instead of ignoring them or considering those parents her foes, she welcomed their concerns, encouraging them to join various committees. Eventually, the parents became advocates of Maxine and the reform efforts at Edison.

Parents are involved with the school in various capacities. The School Improvement Council welcomes parents as members. In addition, some parents, such as Eleanor Smith, volunteer to work at the school. Eleanor first volunteered because she wanted to be with her children. When other parents expressed concern about the reform efforts, Eleanor has been quick to defend Edison and its work with students. Eleanor feels like a valued member of the Edison community and an "essential collaborator."

In contrast, discontent was heard throughout the state. Shortly after Christmas, a group of several hundred protesters turned out for a demonstration at the state capitol. One concern was that students are part of a large educational experiment. Other parents worried about specific parts of the act, such as the ungraded primary school. Other concerns focused on the nature of the 75 outcomes, the validity of the assessments, and the funds necessary to pay for the reform. While some of the protesters wanted to abolish SRA, others simply wanted aspects of the law changed. None of this unrest, however, fell on Edison.

Conclusions

Edison's efforts at reform point to an important lesson. The goals of the school and the goals of the state effort are mutually supportive of each other. Because of the matching of these goals, battles common to reform efforts are minimized. The teachers do not subvert the system; instead, they are eager to refine their skills. The intentions of the reform enhance their efforts rather than form a force to work around. Even the obstacles that block the school from achieving its goals can be addressed through the reform system. Attention to qualities of excellent work are defined through rubrics from the state. As the teachers continue honing their skills, they have the tools that hold the potential for improving the work.

The rumors from other schools raise the possibility that when reform is imposed from the outside, the school community is likely to resist. When a school finds its values confirmed by state mandates, however, the likeliness of the reform effort making a difference in the lives of students is heightened.

IV. CONCLUSIONS AND IMPLICATIONS

Schools in the reform process can learn valuable lessons from Edison. In this setting, the merger of top-down and bottom-up forces intersect, creating a culture of change, risk taking, and reflection. Committed to the CES, Edison teachers search for ways to implement the common principles. In the summers, they travel to Brown University, give up days of their vacation to participate in the school retreats, and study ways to improve their classroom practices. The legislation of the state supports these actions. The power of the legislation cannot be stressed enough. Intentions have been pushed to realities. Plans to improve practices, to implement programs, to restructure assessment practices had to be initiated as a result of SRA. No longer did teachers have the luxury of discussion and consideration. In a school already committed to the assumptions behind the reform, this push enhanced what it was already doing, even adding a note of urgency.

Because the students and the school are annually assessed, the fruits of the labor are up for public picking. If Edison students perform well or poorly, the knowledge is out in the open. The reputation of Edison's innovations is already known throughout the district as well as across the nation. If Edison students do well, the school and the system are particularly vulnerable. One district official dismissed Edison's explanations for their poor showing on the second year SRA assessments. "They've been at it a long time. Wouldn't you think they would do better?" With such pressure from within the home district, Edison is in the position of either retreating from the reform or working even harder.

The big picture of the reform movement is part of the belief system of the school even with the uneven implementation of those beliefs. Students are becoming the workers who must demonstrate their learnings. Curriculum is not isolated bits and pieces, disconnected from each other. Practices, such as writing across the curriculum, are partially integrated throughout the school, no longer just the domain of one discipline. However, the nitty, gritty details of how to best implement these goals are still under study. Edison is not a school that has arrived; it is a school on the way to reform.

Perhaps an analogy to skiing will clarify. When a skier first begins to learn, all his concentration is on the snow plow. His energy is focused on not having the tips cross and being able to make wide turns down the hill. As the snow plow becomes integrated into his repertoire of things he can do well as a skier, he moves into more complicated areas, making parallel turns, learning a rhythm, relaxing. Each spurt of growth is accompanied by an internalization of a skill, moving it out of focused, concentrated attention and into automated routine. Attention is now focused on a new area and will stay focused there until that too becomes routine. The processes under control and away from conscious attention only come forth when the skier wants to refine his skills. Then once more he brings to his attention a skill well routinized.

Schools in the reform process are in a similar state. They pay attention to various parts of the reform process with focused attention until that skill is integrated into practice. The school committed to ongoing reflection and to improvement continues searching for practices which need attention and honing.

Edison has the support in place that will continue moving it along. Continued growth can be found within both the state initiative and CES. Since one of its most glaring weaknesses is its continued emphasis on teachers performing rather than on student performances, CES is equipped to help them make a shift. As part of the Annenberg Institute for School Reform, CES is urging the formation of "Critical Friends Groups" in schools around the nation. The Critical Friends Groups are a means for teachers to receive feedback on their work. Teachers bring to a group of their colleagues work from their classes, and in a very formulaic process, the teachers give "warm" or supporting and "cool" or critical comments (Allen, 1995). The formality of the process creates a safe way to share and places the emphasis not only on what teachers are doing but on the student work. Edison is one of the schools involved in the Critical Friends Groups effort.

Through the Critical Friends Groups, Edison will be able to continue its schoolwide discussions of expectations. As difficult as this is in a large school, those discussions help build common interpretations and meanings. When policies are interpreted as widely as the honors credit policy is, the school is in need of discussions to build consensus about what high quality work means for the school.

The rubrics from SRA provide another avenue for focusing on student work. Because the rubrics define the qualities of excellent and merely adequate work, they serve as useful descriptors that even students could use and understand. Regular use of the rubrics could help internalize the valued qualities for both teachers and students.

One philosophical base of the state's educational initiative is "capacity building." By switching the paradigm from deficiencies of students, the state law builds off the strengths of students. A similar process is called for at Edison. One of the strengths of the school can be seen at assessment time. The school joins forces to create a supportive system for students to demonstrate their knowledge. At this time, students in A.S.P. were most engaged and challenged. If the school were to examine the qualities that nurtured engagement, those qualities could be built on.

And, finally, the school needs to develop a strategic plan for moving forward. The development of the plan could bring various groups around a very large school to discuss expectations, problems, and solutions. Because the goals of the reform movement are defined as a result of Edison's involvement in CES and commitment to SRA, the structure is in place for the school to define its strengths and weaknesses. This strategic plan must include an assessment process which focuses not only on what teachers can do, but on what students should be able to do.

Edison skis well, but it is not at the gold medal level of the Olympics—yet. One of the missing elements from their efforts is a coherent discussion of the meaning of quality. Students write and write longer pieces, but discussion about quality thought is missing. Students add to their portfolios, but the work is often one draft pieces, the rigor of revision of thoughts missing. Students complete exhibitions of learning, showing increased sophistication of presenting ideas to the public, but support for assertions are missing. Rubrics list the work necessary to turn in, but the depth of the thinking and the polish of the product are not included in the list of requirements. Posters showing the difference between novices and proficient thinkers fill the rooms, but rarely do teachers refer to them.

This is not a school in which students are limited by the "basics"; instead it is a school which strives for students to "use their minds well." Students are urged to think about serious issues. Instruction focuses on metacognitive strategies so that students will know how to grapple intellectually with the issues from the past which continue to haunt us. But in this well-nurtured school culture, an element is missing, the element of focusing on the goal of intellectual excellence. Strategies designed to promote thought and practices created for the intellectual challenges are stressed, but the charge of using minds well is subdued.

Indeed, reform is difficult. Pulling all of the pieces together to make for a coherent whole is a long, arduous process. This is a process that must not be shortcircuited because by taking shortcuts the benefits of sustained change are reduced (Wasley, 1994). Edison may not be there yet, but it's moving in the right direction.

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THINKING ACROSS DISCIPLINES
AT
OAKGROVE MIDDLE SCHOOL:

An Investigation of Outcome-Based Education and its Implementation

ERIN ROSEN
CURRICULUM REFORM PROJECT
UNIVERSITY OF COLORADO

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This paper was prepared for the Curriculum Reform Project, a study of curriculum change in mathematics, science, and critical thinking which is funded by a grant from the U.S. Department of Education's Office of Educational Research and Improvement (OERI Grant #R91182001). The opinions expressed herein are those of the author and the participants in this study.

FOREWORD

When faced with a challenge, a detailed story of someone else's experience in a similar situation generally is of strong interest. In reading someone else's story--be it political history, a chronicle of dealing with a family tragedy, or the story of a major business success--we do not expect to find a formula to apply directly to our own situation; instead we hope to find insight and inspiration. Thus, the story contained in this report should be engaging to individuals committed to educational reform in a local school context. It is the story of one school--or department within a school--engaged in fundamental reform of education for its students.

Similarly, one should not expect to find in this case a model for a specific educational reform to initiate in another locality. Every context is different. Each local school and community culture has its distinctions, each individual's and group's educational goals have different shadings, each setting has its own history, and each school has unique constraints to making change.

Not only does one formula not fit all schools, there is no specific formula for a given school. A central message of our case studies is that educational reform is a long-term process for which there is no detailed road map. It is an uneven process with highs and lows, failures and successes, but gradual movement toward greater and more profound learning for students.

What we can expect to find in this story are insights about new teacher roles, how students go about learning with greater depth of understanding, the context in which such shifts can occur, the challenges that must be overcome to initiate these changes, and actions taken by various parties to keep the process of change moving forward. Reflecting on someone else's story can be helpful in the process of developing one's own plans, collaborating with others to move the process forward, and helping students take responsibility for learning.

The Research Project. The case study reported here is one of nine--three each in science, mathematics and higher order thinking across the disciplines--conducted as part of the Curriculum Reform Project. The cases were studies of individual schools--actually a department within a school in the case of science and mathematics--in the process of solidifying reform. Each was selected because it was a successful example of reform. A researcher spent 20 or more days at the site to learn what changes they were making, the barriers encountered, how they overcame these challenges, the nature of their successes and their hopes for the future.

Site Selection Criteria. Sites were sought which had initiated reforms consistent with those recommended by leading groups in the respective field, e.g., the Curriculum and Evaluation Standards for School Mathematics (Commission on Teaching Standards for School Mathematics). Final selections were based on program outcomes including student test scores, enrollments in subsequent elective courses in the given subject area, and professional judgments about the quality of the curriculum provided to students.

Site Selection Process. The search process began with the solicitation of nominations from researchers and knowledgeable practitioners across the U.S. Key people at the nominated schools were contacted by phone to get additional information and written exchange of information followed. Selection according to the above criteria resulted in schools spread across the country with considerable variation in location (e.g., urban vs. rural), economic level and ethnic makeup of the communities.

Research Methodology. In each case the researcher was immersed in the activities of the school and collected a wide range of information. Data included classroom observations, interviews with students, teachers and administrators, and a variety of documents from the site. The voluminous field notes and interview transcripts were analyzed and an interpretative report written.

Cross-site Analysis. A cross-site analysis of the nine cases was conducted to gain perspectives that extend across the sites. An individual case is rich in description and context but does not contain the depth of analysis that can come from looking across a number of cases. Thus, the reader is referred to the Project's cross-site analysis. Main points from this analysis to bear in mind while reading this one case, however, include the following:

- The reforms being sought are profound and demand major changes in teacher and student roles.
- The process for achieving such reforms is complex and demands a long period of time to attain.
- The schools in these cases have traveled a considerable distance on the road to reform but have not yet "arrived."

These cases are presented largely--though not exclusively--from the perspective of the teachers at the center of the cases. This perspective reflects the nature of the reforms and the way they have been initiated in each school. This perspective may be particularly important for initiating change. Our cross-site analysis shows that changes in teachers' values and beliefs--not just greater teaching skills and techniques--are central to reform. While changes in student roles and student work are the ultimate "bottom line," these teacher changes are an important intervening step.

We hope your reading of this case stimulates both interest and significant reflection about reform activities in your school.

Ronald D. Anderson
Director, Curriculum Reform Project
University of Colorado

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I. INTRODUCTION

Pre-Test

In preparation for reading the following case study, please take the following test. In the space provided, please give a short description of the terms that follow. You will not be graded on this assignment.

1. What is Outcome-Based Education (OBE)?

2. What are the three premises of OBE?

3. What are the conditions that schools control?

4. What are the five exit outcomes that Oakgrove students aim toward?

5. What are essential learnings?

6. What are demonstrations?

7. What are the differences between traditional, transitional, and transformational demonstrations of learning?

8. What are rubrics?

9. What are expanded opportunities?

10. What are student-led conferences?

If you are like most of the people who have attempted this Pre-Test, you were probably able to answer one or two of the questions easily, and then you stared blankly at the remaining questions, feeling lost in a sea of jargon.

But if you were a student in Steve Webster's class at Oakgrove Middle School, you would be able to explain what all of the terms mean, how you met the exit outcomes in your latest demonstration of learning, and why you asked for an expanded opportunity to improve the quality of your demonstration.

As an educator, policy maker, or legislator, you might question how these students came to such a high degree of ownership, self-direction, and self-assessment of their own learning. This case study attempts to answer that question by investigating the implementation of Outcome-Based Education (OBE) in one school. Particular attention is paid to the importance of initiating students into reflective practices that enable them to build a conceptual understanding of learning in an OBE context, as well as the importance of providing students with the necessary skills to take control of and responsibility for their own learning.

Although Oakgrove Middle School was selected because of its reputation for work in OBE, it is important to state from the outset that this case study is not meant to be an apology for OBE. While this case study provides a clear and solid example of OBE being implemented, the lesson to be drawn from this example is not so much that OBE is a program to be followed but that the implementation of a philosophy which serves both as a guide and a goal for teaching and learning can lead to increased student ownership, self-direction, and self-assessment of learning.

It is also important to underscore the point that this site was not chosen because of its reform efforts in history, the particular subject area highlighted in the case study. It was coincidence that this site happened to be beginning a reform process of its history curriculum just prior to the site visits. As it turned out, the coincidence happened to be very beneficial because it provided us with an example of the sophisticated level of engagement in curriculum, demonstration of learning, and self-assessment that students can accomplish when the curriculum, instruction, and assessment practices are all tightly linked to the overarching philosophy of OBE.

The Site

Oakgrove Middle School sits in the center of a planned community, a suburban enclave located approximately 60 miles away from a sprawling metropolis. The planned community is a neat network of adobe-colored neighborhoods and shopping centers dotted by young eucalyptus seedlings and an occasional green space. Built in 1987 with the rest of the community, Oakgrove Middle School is the local sixth through eighth grade school. Like the entire community, the school is designed in the style of Spanish architecture, painted subdued Santa Fe colors. The classrooms form a perimeter around a pleasant courtyard wherein students eat lunch and "hang out" during passing periods.

Most of the students live in the planned community although some students ride buses in from the poorer areas of the school district. The 1,300 students are of many different backgrounds: Latino, African American, Asian American, and Caucasian. Within the student population, 346 are with Aid for Families with Dependent Children, 134 are identified as "Gifted and Talented," and 61 students have special education needs. All appear to intermingle freely, taunting one another with middle school pranks and teasings, but almost entirely without a spirit of ill will. The camaraderie between students in the classroom is very apparent; it is as if this is a place where the students want to be. The principal said that the school has had the highest attendance rate figures in the district since it opened in 1987 and that between 1989 and 1992 the average attendance rate at Oakgrove did not go below 96%.

Oakgrove Middle School's reputation as a school where sophisticated learning takes place has begun to attract attention both locally and nationally. In 1993, an article on the school was included in a national education periodical. The article emphasized Oakgrove's high attendance rate, student-led conferences, and general optimistic tone. Additionally, Oakgrove's program for at-risk students was included in a video tape of cutting edge at-risk programs that has been distributed nationally. Its athletics program, which has been touted as one of the best in the country, was awarded a large sum of money by the State Department of Education to refine its program and consider ways that the program can be disseminated to other schools. And, in 1993, the history department was also awarded such a grant—a fortuitous situation for this case study, as the major emphasis of this grant was to reform the history curriculum based on the principles of Outcome-Based Education. The school's high degree of implementation of OBE principles is also well-known within the circles of those interested in the philosophy. With its growing reputation, visitors from all around the country have come to observe the school. In the 1992-93 school year alone, over 2,000 people came through the school to see these various programs in progress.

The principal attributes the school's strength to the high caliber of teachers and to the major philosophies[1] which guide Oakgrove's teachers and their teaching. In Part II, we will define the several different, interlocking components of OBE as it is envisioned at Oakgrove. Here, we describe contextual factors which add to the school's strength.

Background Context

Through site visits, we noted the school's strength arising from not only the teachers and Outcome-Based Education, but also from other factors, such as:

- strong principal support
- teachers' opportunities for professional development
- teachers' opportunities for teaming and/or team teaching

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[1] Oakgrove's "Belief Statements" are included in Appendix A.

- strong district support
- strong community support

These factors combined to establish a very conducive environment for teaching and learning.

Strong Principal Support

Many of the teachers at Oakgrove, as well as administrators throughout the district, credit the principal, Alex Hiatu, for bringing Oakgrove "so far so quickly." They say that his strong, supportive leadership is what has enabled the school to weather the changes of grade levels of students and the turnover of teachers.[2] "I think Alex's one of the most progressive principals that I've ever seen," said one teacher. "If he's going to drive it, and if he's going to set the example, and if he's going to work as hard or harder than I am, then I have nothing to complain about."

Since 1990, Alex's main mission has been to bring the faculty on board with the OBE philosophy. OBE came on the scene for Alex just as he was trying to focus on better ways to provide real learning for students. Alex said that in 1989-90, the test scores at Oakgrove were going up but "kids were still getting lost in the cracks. We were adding programs left and right like you add new coats of paint. But nothing was really reaching the students." In 1990, Alex made his first visit to the High Success Network, an organization based in Colorado which promotes the OBE program, and found that what William Spady was saying "was so wonderful and easy. He was asking things like, 'Why are we averaging?', stuff so simple, and yet we are so ingrained in it."

Alex found the philosophy to be very appropriate for the school and the students. He enthusiastically weaves OBE mottos in and out of his conversations: "Success breeds success," he says. "All students can learn and succeed but not the same way on the same day ... We control the conditions of success ... Our students will be effective communicators, inspired learners, productive workers, responsible citizens, and resourceful thinkers." He rattles these sayings off like a politician, but there is nothing suspicious about him; he stands firm in his commitment and conviction that OBE leads to better learning for kids.

Teachers hired to teach at Oakgrove are specifically asked about their understanding and level of interest in Outcome-Based Education. The principal also looks for teachers who like kids. "I can teach teachers to teach," he said, "but I can't teach them to like kids." In an informal survey conducted at the end of the 1991-92 survey, 86% of the teachers at Oakgrove Middle School replied that they were either content or very enthusiastic with their work environment.

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[2] There was a high turnover of teachers in the first few years of the school. This is because the school itself changed from being a school for grades 3-8 when it opened in 1987, a grades 5-8 school in 1988, a grades 6-9 school in 1989, and since 1990, a grades 6-8 school. Only seven of the forty-five teachers who were at Oakgrove when it opened in 1987 are still with the school.

Alex Hiatu realizes, however, that for many teachers, the link between the OBE philosophy and teaching practices is at first difficult to comprehend. He furthermore understands that once teachers comprehend what OBE is about, many come up against their own natural inertia to change. One teacher told Alex that "OBE means starting all over again." Wanting to be sensitive to these feelings, Alex takes it upon himself to personally work with teachers for whom OBE is a challenge.

Teachers' Opportunities for Professional Development

In addition to the personal support they receive from the principal, the teachers at Oakgrove have many opportunities for professional development which relate to OBE. In the 1992-93 school year alone, the teachers had over eight professional development days dedicated solely to OBE and applications of OBE in the classroom. Five teachers received extensive training on OBE and are now themselves trainers in OBE. These five teachers work with other teachers at Oakgrove who are newer to the philosophy. The principal believes that teaching others the philosophy improves the teachers' practice of the philosophy. "They will practice what they preach if they actually go out and teach it," he said.

Teachers' Opportunities for Teaming and/or Team Teaching

Another contextual factor of the school which supports teachers' learning is the course schedule. The schedule is set up so that every student belongs to a "family" consisting of five teachers: two language arts/history teachers, one math teacher, one science teacher, and one physical education teacher. The language arts/history teachers teach a block period, with a ten minute break in the middle of the hour and fifty minute period. The language arts/history teachers can choose to teach their block period as they wish; they can teach both language arts/history to a single class of students, or they can teach one of the subjects to both groups of students, switching classrooms at the break.

With this flexible schedule, there is a lot of opportunity for collaboration between teachers within the same family. Often, that collaboration involves sharing ideas of how to teach a certain unit, comments on what worked and what didn't work, and suggestions of how to make use of the OBE philosophy.

Another important aspect of the schedule is that every Wednesday is a short day; students go home at noon. This leaves two and a half hours (and oftentimes, more) for families of teachers to meet together to discuss anything and everything from curricular concerns to concerns about particular students. The Wednesday afternoons also allow teachers time to contact parents, catch up on their planning, and collaborate with one another on the curriculum.

Strong District Support

Outside of the school, the district administration is both supportive and interested in what is happening at Oakgrove Middle School. Intrigued by the results Oakgrove was getting with its

OBE program, the district administration invited a representative from the High Success Network to facilitate the district's establishment of a strategic plan. Half comprised of community members and half teachers, advisors, and board members, the 70-member task force has been meeting to determine, with the help of the High Success Network, the direction the district will go. The involvement of the High Success Network in the development of the strategic plan will probably result in the plan leaning toward OBE.

The bent toward OBE is taking the district very far from the traditional modes of instruction that were dominant in the school district ten years ago. The assistant superintendent said that in the first half of the 1980's, the district had a "bad political time which resulted in a wasteland of curriculum and instruction." There was a movement toward "fundamental education" in those years which deeply alienated the staff and community. The staff members were particularly frustrated because they were not experiencing success with their students. At one school, kindergartners were required to be able to count to 100 before they could go on to first grade. "The district was using and encouraging all kinds of failure-producing strategies such as these," said the assistant superintendent.

Now encouraging the OBE philosophy, the district, as well as Oakgrove Middle School, is giving great thought to how the philosophy can best be implemented. In doing so, the opinions of the community to OBE have been taken into consideration.

Strong Community Support

It is well-known that in many places around the country, parents, teachers, and administrators have been debating the soundness and effectiveness of the OBE philosophy. The Association for Supervision and Curriculum Development's March, 1994, *Update* has a four page article on OBE and the March, 1994, issue of *Educational Leadership* is solely dedicated to the debate. However, the debate has yet to enter the Oakgrove school district to any large degree. Only one parent has yet to come to Oakgrove Middle School to discuss OBE, and her concerns were assuaged by talking with the principal. Alex Hiatu anticipates that opposition to OBE will arise eventually, but he believes that good communication with parents can help prevent that opposition from getting out of control. In handouts that he gives to people who are interested in OBE and Oakgrove, Alex includes a page entitled "Parent and Community Involvement with OBE" (see Appendix B).

Also, anticipating questions from parents, the principal encourages students to talk to their parents about the program. All of the teachers focused on in this study had their students show their parents papers on OBE at the beginning of the school year. The students had to bring back the papers with their parent's or guardian's signature confirming that they had read it. One teacher also had students do writing assignments about OBE which the students had to have their parent or guardian read and sign. This same teacher, Steve Webster, personally wrote a letter to his students' parents, which read in part:

> This year, your child will be introduced to Outcome Based Education, also known as **O.B.E.** Students will be asked to demonstrate or '**show what they know**,' with respect to life oriented skills. Some of the skills your child will be learning are: working with others, producing **quality** work, meeting deadlines, taking responsibility, communicating verbally and nonverbally, and organizational techniques. These skills will be taught through 'hands-on' activities and performances, in the subject areas of language arts and social studies. The learning and ingraining of these skills will help each student successfully reach the **exit outcomes**, which are attached to this letter. **Exit outcomes** are the 'be-like' goals we want each child to aspire to become ... (Emphasis present in the text.)

Through this letter, Steve tried to communicate with parents the premises, tenets, and goals that formed the basis of all that was to occur in his course that year. Steve was the only teacher to go to this level of communication with parents.

Another form of communication with parents about OBE occurred during the students' student-led conferences--conferences with teachers, parents, and students in which the students describe their assignments and discuss their strengths and "areas for improvement." In the 1993-94 school year, every student at Oakgrove gave a student-led conference during which they spent a portion of their time telling their parents about OBE and how they have been meeting the exit outcomes. Many parents commented that they were impressed by the perspective their children had on their own education.

Summary

The opportunities teachers had for professional development and collaboration with one another, and the high levels of principal, district, and community support were invaluable to the successful implementation of the OBE philosophy at the school. As such, Oakgrove had very few of the internal or external roadblocks that can derail or undermine efforts toward school reform. At Oakgrove, the staff and students shared a belief that anything was possible. We now turn to look at how Oakgrove made use of its possibilities.

II. THE REFORM CURRICULUM IN PRACTICE

In this section, we attempt to define the premises, tenets, and goals of Outcome-Based Education as they are envisioned at Oakgrove Middle School. In doing so, we will define the terms given to you on your "pre-test." We will also describe how Oakgrove Middle School defines exit outcomes for its students, how it is working to control the "conditions of success," and how it is revising its 7th and 8th grade history curriculum based on the Outcome-Based Education philosophy.

What is Outcome-Based Education?

In *Educational Leadership,* John O'Neil writes that in its most basic form, Outcome-Based Education is "the simple principle that decisions about curriculum and instruction should be driven by the outcomes we'd like children to display at the end of their educational experiences."[3] Putting OBE into practice means determining the desired outcomes for students and then designing curriculum, instruction, and assessment practices so that the outcomes can be met.

There are many different ways of going about putting OBE into practice. At Oakgrove, the OBE program takes its form from the model espoused by William Spady and the High Success Network. The High Success Network states that there are three premises which underline the OBE philosophy. These three premises are:

- all students can learn and succeed
- success breeds success
- schools control the conditions of success

In the High Success Network's publications, the first premise of OBE, "All students can learn and succeed" is often followed by the phrase "but not in the same way or on the same day." Essentially, through this premise, the High Success Network expresses a belief in the capacity of all students to do well and recognizes different students' learning styles and learning rates.

The second premise, "Success breeds success," reflects the belief that when students do well in one area of their schooling, they can't help but do well in other areas. The belief is that a snowball effect occurs when students experience accomplishments and that subsequently they will continue to do well in situations both in and outside of school.

The third premise states that "Schools control the conditions of success." The High Success Network outlines the conditions that schools control as:

- the design and organization of curriculum

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[3] John O'Neil, "Aiming for New Outcomes: The Promise and the Reality," *Educational Leadership,* 1994, Volume 51, Number 6, p.6.

- the emphasis of instruction and what students learn
- how students' learning is assessed and the time given to students for learning

The belief is that if these conditions are controlled and coordinated based on the Outcome-Based Education philosophy, an environment will be created in the school that will allow students to meet the exit outcomes.

Exit Outcomes at Oakgrove Middle School

Central to the OBE philosophy is the idea that the education of students should not occur before outcomes are defined—before practitioners know *the goals* of students' learning. In talking about outcomes, the teachers at Oakgrove use a phrase coined by the High Success Network: "Outcomes are what we want our students to know, do, and be like." In the Oakgrove School District, there is a district-wide agreement on what should result from students' learning—not just on a single assignment, but at the end of their experience within the district. These district-wide outcomes are called "exit outcomes."

Oakgrove School District Exit Outcomes

The District Students will be:

EFFECTIVE COMMUNICATORS who use verbal, written, artistic, and technological forms of communication to give and receive information.

INSPIRED LEARNERS who are accountable for demonstrating, assessing, and directing their present and life-long intellectual growth.

PRODUCTIVE WORKERS who perform collaboratively and independently to create quality products and services that reflect personal pride and responsibility.

RESPONSIBLE CITIZENS who have a global and multicultural perspective and take initiative for the quality of life for self and others.

RESOURCEFUL THINKERS who independently and creatively identify and solve problems through reflection, risk taking, and critical evaluations in a variety of situations.

Table 1

The Oakgrove School District, along with a committee of administrators, teachers, parents, business representatives, and students, designed the five outcomes represented in Table 1. These five outcomes form the basis of what is currently happening at Oakgrove: the curriculum is being revised based on the exit outcomes; the emphasis of instruction and what students learn is being tailored so that students demonstrate that they are meeting the exit outcomes; assessment practices and the time allotted for learning are structured to help students evaluate themselves and their peers in terms of whether or not they have successfully met the exit outcomes. Each of these "conditions that schools control" are described below.

The Design and Organization of Curriculum

At Oakgrove, the teachers share the belief that the curriculum should involve more than textbooks and lectures. The students seem to be aware of the difference between this curriculum and curriculum they had previously. One teacher at Oakgrove tells a story of showing a picture of a classroom in which all the students were Black and the teacher was Caucasian. The teacher asked the class, "What's wrong with this picture?" and one student chided, "They're using *books.*"

With the sense that a curriculum based on textbooks and lectures does not adequately engage students, teachers at Oakgrove are beginning to revise their curriculum. Their goal is to create a curriculum that is "designed down from the exit outcomes." Although "designing down" from the exit outcomes may sound simple, in practice, it is a challenge for many teachers. Several teachers said that when they were educated to be teachers, they were trained to see the goal of curriculum as communicating important information to students. Now, with OBE, they have the additional challenge of designing the curriculum such that students will be led to meet the exit outcomes.

This additional challenge is one that all teachers at Oakgrove face—whether they be in physical education, math, science, language arts, or history. This case study focuses particularly on the history department's efforts to reform the history curriculum based on the OBE principles, a process that began just prior to the site visits for this case study.

History Curriculum Reform. In December of 1992, Oakgrove's history department received a three year $35,000 grant from the State Department of Education to design an innovative history curriculum. The grant received by the history department is one of the state's demonstration grants. Demonstration schools are funded for three years to develop a program or, in this case, a curriculum, that can be used at other schools as well. After three years in the demonstration stage, state grant evaluators will determine if the curriculum developed is ready for dissemination. If so, Oakgrove will be funded for another three years, during which teachers from other schools will come to see what the history department is doing. Oakgrove teachers will also go on the road to other schools to disseminate their curriculum.

For the grant, the history teachers in the seventh and eighth grades are writing four thematic courses: Power and Instability, Human Migration, Beliefs and Organization, and Human Expression. Each course will be a semester in length and will be comprised of four units. By the close of the site visits for this case study, the history department had written and begun pilot testing the four units in the Power and Instability course: Revolutionary War, Slavery, Civil War, and Reconstruction.

In determining what the courses would be and what should be included in each course unit, the department was shaped both by the State Department of Education's curriculum framework for history and the OBE philosophy. The department members concur that they "picked and chose" from the state framework topics when brainstorming the creation of the units. (Breakdowns of the state framework and the specific framework addressed in each course are found in Appendices C and D respectively.)

For all of the teachers in the history department, the history curriculum revision process was the first time they had attempted to design a curriculum so students would be able to meet the exit outcomes as a result of their engagement with it. For many of the teachers, the link between the exit outcomes and specific assignments was difficult to see. Thus, in an effort to make the link between the exit outcomes and the curriculum clearer, the department decided to write the teacher's lesson plans such that on each day the exit outcome(s) being targeted was identified.

In addition, the department decided to identify what the essential learnings were for each course. The essential learnings are the overarching points of the entire course. Each lesson within the four units must be designed so that they emphasize one (or more) of the essential learnings. And the essential learnings must be designed so that, in learning them, students will meet the exit outcomes.

The essential learnings for the course "Power and Instability" are listed in Table 2. The essential learnings comprise the "know" component of the phrase defining the outcomes: "What we want our students to know, do, and be like." One way of looking at the essential learnings is that through learning them and understanding what conflict is, what conditions lead to conflict, and what stabilizers and destabilizers can cause or prevent conflict, students will become "responsible citizens who have a global and multicultural perspective and take initiative for the quality of life for self and others."

The department also decided that these essential learnings should be taught to students prior to their engagement with the curriculum. By knowing what the essential learnings are before engaging in the curriculum, the students would be able to spot the essential learnings as they appeared in their readings and assignments.

Essential Learnings

CONFLICT: A struggle between two or more forces

CONDITIONS that can lead to conflict:
1. Imbalances of power
2. Lack of basic human needs
3. Ideology and perception differences
4. Fear

STABILIZERS
5. Knowledge and understanding of self and others
6. Recognition of rightful claims to power and negotiating the sharing of power
7. Ability and will to conduct conflict—conscious decision to not conduct conflict
8. Clear and precise communications

DESTABILIZERS
9. Ignorance or reluctance to accept others or accept alternative perspectives
10. Reluctance to share power
11. Ability and will to conduct conflict—expectation of conflict
12. Lack of accurate or vague communication

ANALYSIS
A. Conflict can/may appear on a personal, community or global level
B. What leads to conflict on one level can lead to conflict on any level
C. Conflict may exist in apparently peaceful solutions

Table 2

The Emphasis of Instruction and what Students Learn

As hinted at through the discussion of the development and organization of the curriculum, in the OBE philosophy, the emphasis of teacher's instruction is on what students need to learn in order to meet the exit outcomes. The emphasis of the teacher's instruction should be to provide students with opportunities to become skilled at the practices necessary for meeting the exit outcomes. What students learn should be not only information, but how to *make use* of that information in order to meet the exit outcomes. What students do with the information is very important because key to OBE is the idea that students need to be able to *show what they know;* they need to be able to do things that embody their learning. In the terminology used by the High Success Network, students need to be able to "demonstrate" their learning.

In order to illustrate the level of learning envisioned for students by the High Success Network, Spady determined three different levels of demonstrations of learning:

- traditional demonstrations
- transitional demonstrations

- transformational demonstrations

Spady explains that the transformational demonstration is the ideal demonstration, though examples of this level of demonstration are few and far between. Definitions and descriptions of each level follow.

Traditional demonstrations of learning. Traditional demonstrations of learning are the most basic demonstrations. Students who perform traditional demonstrations of learning complete discrete assignments such as "reading passages for meaning, spelling specific words, carrying out specific mathematical operations, drawing particular objects, or locating specific features on a map."[4] These types of demonstrations are, writes Spady, "concrete and content-dependent ...narrow in scope, tightly structured by the teacher, and linked to small, specific segments of curriculum content."[5] The very nature of these types of demonstrations precludes the possibility of students meeting Oakgrove's exit outcomes. Because the tasks are determined solely by the teacher and are task-oriented, students do not have the opportunity to take control of, be responsible for, or initiate their own learning. Moreover, they do not have the opportunity to meet the exit outcomes, to show themselves to be effective communicators, inspired learners, productive workers, or resourceful thinkers.

One example of a traditional demonstration of learning is the pre-test to this case study. Here you were tested simply on whether you knew the information or not. You were not asked to apply your knowledge to any real-life situations, to compare or contrast different theories of education, nor to make any judgments about any of the points.

But doing demonstrations such as these would still be traditional demonstrations of learning, says Spady, although he grants that demonstrations such as these are a bit more sophisticated. Spady writes that demonstrations which involve "structured task performances" such as "writing a paper explaining a specific topic; carrying out a laboratory experiment and comparing its results with established theory; or drawing a map of a region at a specific point in history and contrasting it with a contemporary map of the same region"[6] still ask little of students in terms of "ownership, self-direction, and self-assessment."[7]

Transitional demonstrations of learning. As with the category of traditional demonstrations of learning, Spady outlines two levels of transitional demonstrations of learning. At the more basic level of transitional demonstrations, students utilize their knowledge by "analyzing concepts and their interrelations; proposing solutions to multi-faceted problems; using complex arrays of data and information to make decisions; planning complex structures, processes, and events; and communicating effectively with public audiences."[8] Going a step further, at the higher level of transitional demonstrations, students exhibit a larger degree of self-initiative through designing "their own projects, defining the parameters, criteria, standards, and modes of execution and evaluation."[9] Though labeled "transitional," demonstrations at this level are nothing to laugh at. Transitional demonstrations of learning are, as Spady writes, "relatively complex" and "require substantial degrees of integration, synthesis, and functional application."[10]

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[4] William G. Spady, "Choosing Outcomes of Significance," *Educational Leadership*, 1994, Volume 51, Number 6, p.20.

[5] Spady, pp.19-20.

[6] Spady, p.20.

[7] Spady, p.21.

Transformational demonstrations of learning. Transformational level demonstrations of learning are put forth by the High Success Network as the desired level. Transformational demonstrations of learning not only involve the qualities inherent to traditional demonstrations, but go a step further to have application to real life situations. Utilizing their knowledge from many different areas, students carrying out transformational demonstrations do such things as: organize and facilitate a debate with students, teachers, and community members on an issue of importance to the community; write and then carry through a proposal for developing a community garden; or organize and facilitate a peer-advisor program between students at the middle school and elementary school levels. Demonstrations such as these "require the highest degree of ownership, integration, synthesis, and functional application of prior learning because they must respond to the complexity of real-life performance contexts."[11] When students carry out demonstrations such as these, it is very clear to the teacher and student that the student is meeting the exit outcomes. Techniques for assessment are described next.

Assessment of Learning and the Time Given to Students for Learning

How the student's learning is assessed and the time given to students for learning are the final conditions that schools control. In terms of assessment, Spady writes that students who are at the point of giving transformational demonstrations of their learning exhibit "a high degree of ownership, self-direction, and self-assessment."[12] In terms of the time given to students for learning, the High Success Network promotes the phrase, "*When* students learn something is not as important as *if* students learn something."

At Oakgrove, ownership, self-direction, self-assessment, and time given for student learning are encouraged through three different strategies:

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[8] Spady, p.20.

[9] Spady, p.20.

[10] Spady, p.19.

[11] Spady, p.19.

[12] Spady, p.21.

- rubrics
- expanded opportunities
- student-led conferences

Each strategy is intended to encourage the students to develop a habit of evaluating their own learning.

Rubrics. There are many different ways to design rubrics. At one extreme, rubrics can be lists determined by the teacher which outline "mechanical" requirements of assignments, such as how many paragraphs an essay requires, how many sentences need to be in the opening paragraph, how many words the assignment needs to be overall. At the other extreme, rubrics can be lists designed by the student which describe the standards for student work: that the work needs to involve a "better than best" effort, that the work needs to be explained and justified in the students' own words, that the work does not "leave out" anything.

The former type of rubric is an assessment tool likely to be used with traditional demonstrations of learning, where assignments are narrow in scope and tightly structured by the teacher. The latter type of rubric is more likely to be used in conjunction with transitional and transformational demonstrations of learning, where students have more room for initiation, control, and responsibility in their learning.

Expanded opportunities. At Oakgrove, "expanded opportunities" are often used in conjunction with rubrics. In an attempt to discourage grades from being the motivator for students to engage in assignments, Oakgrove implemented an "A, B, I" grading policy. With the policy, students are given an "Incomplete" if they do not meet the requirements of the assignment, and then are given an "expanded opportunity" or a "second chance" to do so. When the requirements are met, the students are given an A or B depending on the quality of their work. Teachers can also give the students further expanded opportunities to raise their grade up to an A. At the end of the semester, those with incompletes received C's, D's, or F's, depending on their work, so the full range of grades still appeared on the students' report cards. But the hope is that by using the "A, B, I" scale during the semester, the students will take the expanded opportunities offered to them to meet the requirements as outlined by their rubrics.

Student-led conferences. The other strategy used at Oakgrove Middle School to encourage students to assess their own work is the student-led conference. In the 1994 January-February newsletter sent out to parents, the principal wrote, "Student-Led Conferences are conferences that share your child's strengths and areas for improvement. The difference between these and regular conferences is that your child will facilitate the conference by being responsible for much of the dialogue. This enables them to gain skills in self-assessment and communication. What better way of understanding one's academic needs than to have one verbally share one's progress?"

In the student-led conferences, all students discuss their academics, behavior, citizenship, study skills, strengths, and weaknesses. With portfolios of their work from all of their classes, the students explain to their parents and teachers what they did well and what they need to improve upon. They also explain what the exit outcomes are and how they meet them in their classes. The student-led conferences provide a forum for students to step back and evaluate their progress.

Summary. Outcome-Based Education as it is implemented at Oakgrove Middle School has several interlocking components: exit outcomes; the design and organization of curriculum—including the use of essential learnings; the emphasis on instruction and what students learn—including the capacity to demonstrate their learning; self-assessments and expanded opportunities for students to improve their demonstrations of learning.

For some teachers, the connections between all of the components are very difficult to see. For others, the connections readily make sense. Of the four teachers involved in this case study, only one teacher was of the latter category. This teacher, Steve Webster, was able to "control the conditions of success" so that his students practiced a high degree of ownership, self-direction, and self-assessment in their learning. The implementation of OBE in Steve's class and the two other history classes is described in the next section.

Focus of the Case Study

Upon the first visit to Oakgrove, three different courses were identified for this case study. Four teachers from two different families taught these three courses. The history/language arts teachers in one 7th grade family, Steve Webster and Lisa Dallins, taught two separate classes of students. These classes were identified as being important to look at because they appeared to be making more attempts than other teachers to use the premises, tenets, and goals of OBE as the basis of their instruction. The history/language arts teachers from the other family, Carl Larsen and Patrick Wykoff, team-taught one class of eighth grade students. While they were not very active in using OBE principles in their classroom, they were the primary directors of the history grant, and thus it appeared valuable to work with them closely as well.

The study captured these classes at a very key point. In the first semester, the history teachers were involved in the writing of the new history curriculum. The classroom observations during the first semester, therefore, showed the teachers implementing a curriculum that, except in Steve Webster's class, had not been designed with OBE premises, tenets, and goals in mind. Of the four teachers, only Steve Webster dedicated significant time in the first semester to guiding students to consider the OBE philosophy and the purposes of their learning. And only this teacher designed curriculum, instruction, and assessment practices with the OBE philosophy in mind. As we shall see, in the first semester students in this class developed habits of engaging in curriculum, demonstrating their knowledge, and evaluating their own learning—habits which they readily employed when the new history curriculum was implemented in the Spring semester. The students in the other two classes did not develop habits such as these and were therefore unable to achieve the same success with the new curriculum that Steve's students did.

Although it may have been valuable to conduct this case study at a later date, when more teachers made use of the OBE philosophy to a greater extent, the contrast between Steve Webster's students and the students in the other two classes provides valuable insights on the importance of initiating students into a reflective practice that enables them to build a conceptual understanding of learning in an OBE context, as well as the importance of providing students with the necessary skills to take control of and responsibility for their own learning.

Initiating Students into Reflective Practice

The students in the three history classes in this study were initiated to very different levels of reflective practice, levels which ranged from no reflective practice to consistent reflective practice. Only one of the three classes spent substantial time on the premises, tenets, and goals of OBE. By doing so, students came to a conceptual understanding of what it means to learn in an OBE context, an understanding which motivated them to engage fully in the curriculum and carry out sophisticated demonstrations of learning and self-assessments.

No reflective practice: Patrick Wykoff's and Carl Larsen's students. Patrick Wykoff and Carl Larsen's class began right away with what Spady would term "traditional demonstrations of learning." Students chose a book to read, read 20 pages a day, and began a reading journal in which they described the plots and characters of the book that they were reading. Their parents were asked to initial their reading journals every night, indicating that indeed their child had read the required 20 pages. Periodically, the students would write book reviews on books they had finished.

Starting the year off in this way, the students were given no initiation into the premises, tenets, and goals of OBE. This was very obvious during an interview with a student:

Interviewer: *Do you talk about OBE in this class?*

Student: What's that?

Interviewer: *Outcome-Based Education.*

Student: No.

Interviewer: *Do you talk about what quality work is?*

Student: No.

Interviewer: *Do you talk about rubrics?*

Student: Yes, a little bit.

As this conversation and another conversation with four students went on in this vein, it was clear that Carl's and Patrick's students did not have any grounding in reflective practice based on OBE premises, tenets, and goals.

Reflecting on the self and the other: Lisa Dallins's students. Lisa Dallins's students began the year by reflecting on issues that related to themselves and their peers. The central topic that Lisa used for beginning discussions among the students was discrimination. In class, Lisa told stories about ways that she had experienced discrimination, thus opening the doors for the students to describe their own experiences with discrimination. The students discussed several different forms of discrimination, including racial, gender, age, and weight discrimination. Approximately 75% of the students were of color, and hence many of the stories dealt with racial discrimination. This activity served to inspire students to reflect upon their personal opinions of important social issues and to create bonds of understanding between the students. Throughout the year, students often entered into spontaneous discussions of important contemporary issues. In fact, the students in this class exhibited a level of personal vulnerability not visible in either of the other two classes studied.

Yet this eagerness to debate and discuss was not paralleled by an eagerness to participate in written classroom and homework assignments. As will become evident, when students were allowed to discuss an issue, or when the task at hand was very clear, they were very attentive and excited about in their work. But when the students were asked to design something of their own, to put something into their own words, or to complete a series of assignments, the majority of students failed to complete the assignment. These students seemed not to have a sense of the importance of completing assignments, nor of the outcomes to which their assignments were to lead them.

On the same day that Patrick and Carl's students were interviewed, a few of Lisa Dallins's students were interviewed as well. One of them, Student A, had a general sense of what OBE was: "OBE is Outcome-based Education. By the end of the year, teachers want us to know the steps of a good education. Every teacher has it set up so that by the end of the year, every kid knows OBE." When asked, "So when you know OBE, what does that mean?" the other student, Student B, said he didn't know. "Well, let's see, OBE means Outcome-based Education. Does that mean you're supposed to get to a certain point?" "Yes, by the end of the year," said Student A. "You reach a goal," said Student B. "A goal. And how do you know what that goals is?" the interviewer asked. "Well, it's kind of the teachers will tell you what they're looking for and then you can go and add different things. All the teachers have a list of what OBE is in their classrooms on the wall. So you can look at that and that's OBE," said Student A.[13] They were asked if it helped to know what teachers were looking for, and they both said yes. They were asked if the things the teachers were looking for were called outcomes and Student B said that he was absent that day. They said that Ms. Dallins went over the list of things such as exit outcomes and rubrics once and then they copied down the terms onto paper and put the papers in their three ring binders.

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[13] A depiction of the poster described by the student can be found in Appendix E.

Like Carl's and Patrick's students, Lisa's students were not initiated into reflective practices at the beginning of the year that would enable them to build a conceptual understanding of learning in an OBE context.

Reflecting upon the tenets and terminology of OBE: Steve Webster's students. In contrast to Lisa's, Carl's, and Patrick's students, from the very beginning of the school year, the students in Steve Webster's class began to grapple with OBE. Over the course of two weeks, the students had five different assignments relating to exit outcomes, quality, and tools for assessment. For example, on September 10, students were asked to define the following terms: exit outcomes, outcomes, performances, rubric, creative risk taking, expanded opportunities, justify, analyze, evaluate, and deadlines. Unlike your pre-test, in defining these terms, the students were to give examples from their own life in explaining what the terms meant. The students were also given "expanded opportunities" to improve the quality of their work.

On September 16, students began to examine the term "quality" by giving five definitions of the word and ten explanations of what made a quality employee and a quality student. On September 17, students, with Steve Webster's help, created a "performance rubric" which included the following components: making good eye contact, speaking loudly, showing emotion, performing for at least one minute, including an introduction, using body language, speaking clearly, having an ending, memorizing lines, asking people if they have questions, and answering with a good answer.

On September 18, students surveyed three people in the school—students or faculty members—with three questions: "What is your definition of quality?", "What is your definition of a quality employee?", and, "What does quality have to do with the exit outcomes?" Students created both a draft and a final copy of their survey. On September 21, students surveyed a parent or guardian with one of the above questions.

Then, on October 6, the students played a Jeopardy-like game in class. The students were divided into four teams. Turn by turn, a member of the team selected a topic from the following choices: History, Television, Outcome-Based Education, Inspired Learner, Productive Worker, Resourceful Thinker, Effective Communicator, Responsible Citizen. The categories having to do with OBE and the exit outcomes were picked as often as the "History" and "Television" categories.

These assignments initiated the students' thinking about their visions for their schoolwork, the level at which they would demonstrate their learning, and methods for evaluating their schoolwork and that of their peers. By going over and over the premises, tenets, and goals of OBE, the ideas became deeply ingrained within them. As will be evident in further descriptions of the students in this classroom, this conceptual understanding provided them the training and tools necessary to take control of and responsibility for their learning.

This is not to say that the students always took responsibility for their learning—many times the students got "off task" while in their groups (discussing the merits of certain comic books or gossiping about other students), but a quick reminder from Steve, "Are you doing quality work?" would get them back on task. Nor did they always complete their homework assignments; Steve gave a lot of "expanded opportunities" to those who came to class empty handed. But as the year went on, expanded opportunities were less frequently given out. When the students had been given sufficient advance notice of due dates and had not used their time responsibly, Steve refused to give them expanded opportunities. Meeting deadlines was extremely important in Steve's class, evidenced by the list of assignments on the chalkboard in the middle of the year:

> Things that will soon be due:
>
> 1. March 15th. Tableau practice run. You must have: your background completely done. Your costumes finished. All of your lines memorized.
> 2. March 16th. Tableau final grade.
> 3. March 18th. Reading Log #3. Your 1st book of the month should be finished by 3/25.
> 4. Binder Reminder completely filled out with grades.
> 5. Knights of the Reading Round Table due date April 22nd.
> 6. Home Conference (Student Led) due April 29th. Make sure you did your letter and parent letter.

Here, the students were being reminded of their assignments for the next month and a half. With such advance and explicit notice, they had no excuse for not taking responsibility for their work. With Steve's consistent reminders, the students seemed to understand that how they did in school depended on *them*, not him.

In talking with Steve's students, it was obvious that they understood what OBE was and how it related to them. When asked what an outcome or an exit outcome was, one student said, "Something very important. They want us to know all the stuff so we're prepared when we go to high school and when we leave." "What they want you to do when you leave here, what they want you to learn here, what they want you to become," said another student. This student's comment echoed strongly of the phrase, "an outcome is what we want students to know, do, and be like." It was clear that this was a phrase that was often used in this class.

When asked whether they were being encouraged to think for themselves, the six students responded in unison, "*Yeah!*" "He wants us to be like in the exit outcomes—inspired learners, productive workers, communicators, thinkers, and what's the other one? Oh yeah, responsible citizens. Those are the exit outcomes that he wants us to meet all the time. That's what we try to do," replied one student.

The students said that the way they remembered all the definitions was "We read it a lot and then we just pick up on it," said one student. "We hear it every day," said another. "He's usually *always* talking about it."

Summary. The students in these three classes received very different initiations into the school year. In Carl's and Patrick's class, the emphasis was more on the completion of discrete tasks than the quality of work done on the tasks. In Lisa Dallins's class, the emphasis was more on personal expression and reflection around questions of identity rather than visions for curriculum work, quality, and self-assessment. In Steve Webster's class, the emphasis was more on outcomes, demonstrations, and assessment than on personal stories or discrete tasks. As the year progressed, it was apparent that the students who had spent the most time in reflection on the purpose and process of engagement in curriculum were also the most avidly involved in their coursework. Levels of engagement in curriculum are addressed next.

Engagement in the Curriculum

The level of involvement in reflective practices had direct parallels with the level of engagement students had in the curriculum. Here "engagement in curriculum" means not only attentiveness and participation during class, but also commitment to seeing assignments through to their completion. The types of engagement in curriculum in Carl's/Patrick's, Lisa's, and Steve's classes can be classified as passive, occasional, and extreme, respectively.

Passive engagement in the curriculum: Patrick Wykoff and Carl Larsen's students. Patrick's and Carl's students were passively involved in the curriculum. The reasons for their passivity were not hard to determine: the students were only given discrete tasks to complete and almost never had room for creativity in their assignments. Essentially, the only level of engagement they could have in the curriculum was passive engagement.

For example, during a site visit early in the year, the students had just started reading and discussing Willa Cather's novel, *My Antonía*. "Open your books to page 8 for me, page 8," Patrick said. When students had done so, he began to lecture:

> Now, we did get some further information here about this route, about this travel route. First of all, I'm thinking they lived somewhere on this coastal plain, we get hints about that, and he talks about the sea, and you say to yourself he had to live close to the sea because people didn't used to just take off and go to the beach if it took four days to get there. It isn't like we live, they can't just say, yeah, I'm going to the beach this weekend ... The book tells us that they went up through Chicago and they made a stop in Chicago before heading back down into Nebraska ... The only way we know about them stopping in Chicago is that he mentions it. So what does he talk about, what do we know about their arriving?
>
> *Student: It was bumpy.*
>
> Bumpy, yes. And the wagons didn't have any springs. And what were the roads like in these days?
>
> *Student: Rocky.*
>
> Non-existent really, it was a trail kind of thing, you know? Anyway, that brings us up to today. Have we met anybody in the story? Grandma? Is there anything you can tell me about Jim's past? How about this guy? What about Jim's life as an old man? Jim's profession is what?
>
> *Student: Lawyer.*

> Yes, a lawyer. And he's a lawyer for what? The railroad ...

The discussion continued as such for about ten more minutes, with Patrick doing most of the talking and the students feeding in bits and pieces. Then the students read paragraphs of *My Antonía* aloud, with Patrick interrupting them to comment on a few details here and there. The students kept a reading journal to record descriptions and quotations by the characters in the books they were reading. At one point, Patrick said, "Let's get out our journals and put that down as one of the things that Grandmother says." At another point he said, "Here we go with Mr. Shimerda. If you're ready with your page for Mr. Shimerda you can write down this description."

Quite simply, the students were told what to do, they were given their teacher's analysis of the reading, they were told what passages were most important, and they were directed where to write down the designated information. The structure of the class did not inspire the students to be actively involved in the class; in fact, while they were being read to and told what to do, some students read other books that were hidden inside their copy of *My Antonía*, other students passed notes to one another, and others paid attention, though without any enthusiasm.

Carl's teaching style was very similar to Patrick's, so the students did not experience any difference between the two. Nor did the students' level of engagement change when the new history units were implemented in the Spring semester. The pattern where the teachers did most of the talking and the thinking while the students passively listened endured, despite the fact that the units were designed so that the students would initiate and demonstrate their learning. This pattern endured because neither the teachers nor the students had the conceptual understanding of how students could be able to initiate and demonstrate their learning.

Occasional engagement in the curriculum: Lisa Dallins's students. Lisa's students alternated between being extremely engaged in the curriculum and being very dispassionate about their assignments. Take, for example, the student's engagement in the unit on Africa. For this unit, groups of students read, researched, and wrote about a specific tribe in Africa, including the nature of their family structures, their religion, their government, their climate, their trade, and their "downfalls." In groups, students drew maps, created masks, and wrote folktales (tasks that Spady would classify as traditional demonstrations of learning). During one class, the students from the Ghana tribe worked together to draw a map of the country. One of the students found Ghana on the map of Africa in the "A" encyclopedia: "Found it!" "Where, where's Ghana?" asked another student. "There." "Hey, it's small!" said another student, "And there's Congo!" They continued in this vein all through the period, excitedly sharing information within the group.

Yet when it came to the day of presenting information from the groups to the class, many groups had not completed certain requirements of the assignment, and many of the requirements were done very quickly, and, hence, poorly. The presentations were also very weak; even the Ghana group spoke disinterestedly about the tribe. Two of the students spoke so quietly they were almost inaudible, and there was no organization between what the different students were saying.

Although Lisa offered them an "expanded opportunity" to improve their grade from a B-, they declined. When asked about this, they said that it was "just good to get it over with."

For another assignment, an assignment in the new Slavery Unit, students were to find an article in the newspaper of a present-day enslaving system or condition, and write a short paragraph explaining it. Only four students did the homework assignment. A fifth student didn't find an article but wrote a short paragraph on how he thought jails were a form of slavery. This student and those who had completed the official homework assignment read aloud the articles and what they had written to the rest of the class. Then Lisa expressed her frustration about all the other students who had not done the assignment, but said that they might as well try to have a discussion about the topics in any case. By the end of the period, all of the students had contributed to the heated conversation regarding issues of race, politics, welfare, and immigration. However, only four of the students had facts to draw upon because they were the only ones who had done any research for the class; the rest of the students had only their personal opinions to draw on. This example shows, again, the excitement with which students would engage in spontaneous debates and the apathy with which they would complete assignments.

Extreme engagement in curriculum: Steve Webster's students. Much of the curriculum in which Steve Webster's students were engaged during the first semester related to assignments on the OBE philosophy, such as described above. Gradually, the students engaged in assignments that weren't about *defining* the terminologies, but *using* the terminologies. For example, students presented dramatic scenes from their favorite T.V. show or movie. In groups, students developed a rubric for their presentation, wrote a script, practiced the presentation, and then performed the skit for the class. In keeping with the "performance rubric" described above, the skits included introductions where students talked about the rubric they used to design their performance. At the end of the performance, the groups explained what exit outcomes they had demonstrated through their skit. The audience then told the students if they agreed, if they thought they had met additional exit outcomes, and if they thought they had fulfilled the rubric that they had set out to fulfill. The group then had the option of taking an "expanded opportunity" in order to better fulfill the requirements of their rubric. Every group making a presentation decided to take the expanded opportunity, hoping to become more "effective communicators" and do "better quality work."

Through these activities, the students became accustomed to demonstrating their learning and carrying out peer- and self-assessments based on their understandings of the exit outcomes and "quality work." Simultaneously, their understandings of the exit outcomes and standards for self-assessment spurred them on to deep engagement in their work. It was as if the conceptual understanding gained through reflective practices served as a point of entry for the students. With a deep sense of why the work was important (their knowledge of the exit outcomes), and what kind of work was valued in the class (their knowledge of quality and their use of rubrics), the students entered into engagement with the curriculum with enthusiasm and commitment, qualities which stayed with them throughout the school year.

Summary. These three classes show very different levels of engagement in curriculum. In the first example, the teachers, Patrick and Carl, held such a tight rein on classroom activities that the students were unable to engage in the curriculum in any intensive way. In the second example, Lisa Dallins's students showed a propensity for engaging in discrete tasks and spontaneous debates yet a lack of commitment to completing assignments. In the final example, Steve Webster's students were consistently deeply engaged in the curriculum, participating attentively during class and seeing assignments through to their completion.

The difference between Steve's students and Patrick's, Carl's, and Lisa's students was that they had begun the year with an initiation into the goals and purposes of their learning, and therefore had a deeper commitment than the other students to meet those goals and purposes. At the same time, by providing the students with the capacity to see the goals and purposes of their learning and by giving the students the tools they needed to take responsibility for their learning, Steve established a classroom environment wherein the students could deeply engage in the curriculum. Because the other teachers did not dedicate any time to creating these capacities in their students, the classroom environment did not support a high degree of engagement in the curriculum.

Another dynamic that is evident from the descriptions above is that the patterns of student engagement in the curriculum that were established during the first semester carried over into the second semester when the new history units were implemented. It is clear, therefore, that the curriculum alone can not inspire students to deeply engage in their work; the students need some kind of philosophical understanding of why it is valuable to enter into work with the curriculum. In the next section, a similar dynamic is evident: patterns of demonstrations of learning that were established in the first semester continued in the second semester.

Demonstrations of Learning

The students in the three classes demonstrated what they had learned through various assignments. Using Spady's definitions of levels of demonstrations, their demonstrations were at two levels:

- low-level traditional demonstrations of learning
- transitional demonstrations of learning

Carl's, Patrick's, and Lisa's students were only capable of giving low-level traditional demonstrations of learning. Carl's and Patrick's students were never asked to attempt anything more sophisticated than this level of demonstration, either in the first or second semester. In the second semester, Lisa's students were asked to give transitional demonstrations, but because they had never given demonstrations in the first semester, they were not skilled in doing so. On the other hand, by the second semester, Steve's students were able to present transitional demonstrations which were "relatively complex" and which "required substantial degrees of integration, synthesis, and functional application."[14]

Low-level traditional demonstrations of learning: Patrick Wykoff and Carl Larsen's students. In the first semester, students in Carl's and Patrick's class demonstrated their learning through the entries in their reading journals, two book reports, one poetry writing assignment, and one project where they developed a game based on *The Diary of Anne Frank*. For each of the assignments, the students were given precise directions of what to include. These demonstrations of learning were "narrow in scope, tightly structured by the teacher, and linked to small, specific segments of curriculum content."[15]

During the second semester, the students began to work on assignments from the new history units. During one site visit, the students did an assignment from the American Revolution unit. For this assignment, the students developed a timeline of the events leading up to the American Revolution. In groups, the students placed events on the timeline, wrote a brief description of the event, and wrote down which essential learning was demonstrated in each event. The students worked well together, drawing neatly on butcher paper and consulting one another on what should go where. One student asked Carl if they needed to explain *how* each event demonstrated the essential learning. This step would have gotten the students thinking more about the nature of each event and the qualities of conflict, power, and instability that each event had, but Carl said that no, they didn't have to worry about that now. Although one of the exit outcomes for that day was for the students to show themselves to be resourceful thinkers, it was questionable how the assignment as Carl implemented it challenged them to do so.

This activity was indicative of the level of demonstrations expected in this classroom all year long—demonstrations which were very straightforward, which required more organization than innovation, which did not demand a high degree of engagement, and which didn't push the students toward meeting the exit outcomes. This activity represents the extent of what Carl and Patrick expected their students to do. Students were not expected to consider if their demonstrations of learning reflected the "essential learnings" or the exit outcomes. They were not expected to integrate or synthesize ideas. They were not expected to take control of their learning or apply their learning to any real-life situations. Moreover, if they *had been* expected to demonstrate their learning in a level higher than a traditional demonstration, the students would have had great difficulty doing so because they had not developed any conceptual understanding of how the exit outcomes related to their demonstrations and because they hadn't been taught any tools for taking control of their own learning. Instead, the students simply did what they were told.

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[14] Spady, p.19.

[15] *Ibid.*

Low-level traditional demonstrations of learning: Lisa Dallins's students. In the first semester, Lisa's students demonstrated their learning through the creation of buttons that expressed their opinions regarding discrimination (i.e., "Don't discriminate!"), writing reports on different tribes in Africa, creating masks for these different tribes, and presenting their information to the class. In the second semester, students began assignments from the Slavery Unit of the Power and Instability course. During a classroom observation early in the Spring semester , Lisa handed out packets to students which contained information about slavery in Ancient Greece, the Hellenistic World, Medieval Europe, and Rome, as well as information about slavery during the Renaissance and during 15th through 18th centuries. Each student received a packet and each group of five or six students was to become "expert" in a particular area (Ancient Greece, Medieval Europe, Rome, etc.) Their assignment for the next day was to give a presentation of their information based on their group's information.

After explaining the assignment for the next day, Lisa did the section on Rome with the students as an example. Each student read the first paragraph to themselves and then they discussed it as a class. Lisa asked them what was the most important point of the paragraph and what did the paragraph say about how slavery was viewed in Rome. Only a few of the students offered answers. Lisa was aware of this and said, "I'm losing you, people." She ended up showing the students which sentences should be underlined. The students had difficulty doing what Spady identified as a traditional demonstration of learning—reading passages for meaning.

This was also the case the next day. The students had divided their information into parts so that each student was responsible for one paragraph. One by one, the students read the summaries they had put together on their paragraph. The first student to read simply recited the first paragraph from the handout. Lisa asked this student if he could restate the paragraph in his own words and he said no. She asked why not and he said "Because." She asked if the activity was difficult for him and he said yes. She said, "OK, that's all you have to tell me."

The other students paraphrased their material from their handouts, but did not stray very far from the handout's vocabulary or structure. None of the students explained the information by comparing it to a current situation or an example that would have been relevant to other students' lives. Although the outcome listed on the teacher planning sheet for this assignment was "inspired learner," none of the presenters seemed to have really learned their information. Also, by breaking the information down into paragraphs, with each presenter only responsible for one paragraph, the presenters didn't have to learn each other's material.

It is therefore questionable how much the "audience" learned from the presenters. Because the presenters themselves didn't have a holistic understanding of their assignment, and because they didn't put the information into "student language," their presentations were very difficult to understand. Furthermore, the students didn't appear to be very comfortable in front of the class and they didn't fulfill the notion of a "performance rubric" at all—there was no eye contact, little projection, and nothing exciting in terms of posture, gesture, or audience involvement. In other words, they didn't deliver the information in a way that facilitated learning by the audience.

In this example, the students were being asked to do things which they had little practice in doing—making *use* of information by giving a demonstration to the class. Although Lisa prodded the students with comments like, "Let's make this more interesting!", "Let's see some energy here!", and "Let's hear you *relate* to this information!", the students were both incapable of and uninterested in doing so. Because they did not have any background in these skills, the students were unable to perform anything more than a rudimentary, traditional demonstration of learning, and many students had difficulties doing even that. What is more, the students didn't have any sense of *why* they should try to put more into their demonstrations; they didn't have any sense of a goal or outcome for their work.

Transitional demonstrations of learning: Steve Webster's students. In contrast to the students in the other two classes, Steve Webster's students gained practice demonstrating their learning from the very beginning of the school year. By March, students were able to give sophisticated transitional demonstrations of their learning. The demonstration of student learning observed then was a "tableau assignment" for the Slavery Unit. In the tableau performance, students were to link an example of slavery from the past to a present-day "enslaved" situation. Students had been given the same packets of information on slavery in different societies as Lisa's students. Prior to the tableau assignment, Steve's students had learned the information through activities such as preparing posters on the different societies, presenting the information to the class, and performing skits which illustrated how slaves were treated in that society.

One day while students were preparing their tableau performance, they were asked about the posters which were rolled up at the back of the room. A girl unrolled one and, even though she hadn't worked on the poster, she was able to talk about slavery in Medieval Europe and how slaves were treated there. A few minutes later she pulled out her own poster and enthusiastically explained how the pictures depicted what slavery was like during the Renaissance.

The next day, the students presented their tableau performances. Six to eight students performed as a group, with half of the students playing characters depicting slavery in a society in the past and half playing characters depicting an enslaved situation in the present. In writing the scripts for the performance, the students were to make sure that there were connections between the two depictions of enslaved situations. In addition, all of the students wrote monologues for their own characters, telling how they came to be in their present situation and how they were presently experiencing conflict.

The students would step forward and give their monologues when Steve, holding a sword, would interrupt the students' presentation by pointing his sword at one student, and say, for example, "Stop. Slave owner in the past step forward." The rest of the students would freeze as if in a tableau—hence the name of the activity.

One of the groups to present included seven girls, three depicting a scene of the "African slave trade in the past" and four depicting a scene inside a temporary agency for maids in the present. The group in the past included a queen, a European who traded weapons for slaves, and a slave whom the queen said did not speak English. The main action in the past involved the trading of weapons for the slave.

In the present, a woman who owned a hotel came into the temporary agency for maids because she needed a maid to help at the hotel. The owner of the agency introduced the hotel owner to two maids, an English-speaking Caucasian maid who had dropped out of high school and was lazy, and a well-educated, Spanish-speaking Latino maid.

When interrupted, the individual characters came forward to tell their own stories. The queen said that she traded slaves for weapons with the Europeans because she needed weapons to fight the wars and Europeans needed slaves to do the work. She added that she didn't care what people thought of her because she was the queen and people had to do what she said no matter what. The slave in the past came forward and said that she was forced to be a slave because the queen needed something to trade with the Europeans to get weapons so that she could eventually rule over the Europeans. "I don't think this is possible," she said.

She added that she actually did know how to speak English but pretended that she didn't so that she wouldn't have to work as hard. The European came forward and said that she traded weapons for slaves because she had more weapons than she needed and fewer slaves than she needed. She said that if the slave couldn't speak English it wasn't a problem but if the slave didn't do the work, she would be beaten.

Next, the owner of the temporary agency came forward. She said that she thought her temporary agency was a good thing. Although her agency received 25% of the maid's earnings, it helped people get jobs. She said that some of the maids came from other countries where they had good jobs, but because they didn't know how to speak English, they had to be maids. Other maids came from this country but were "dropouts and lazy" so eventually they would come to the agency to get a job. She said that she thought the maids were enslaved because they had to do what other people said, but that they weren't enslaved like the Africans because they weren't beaten.

The lazy maid then came forward and said that she was lazy, didn't have any references, and didn't finish high school because she didn't like to do the work. She said that she was enslaved because she was told what to do but she didn't like to work. The Spanish-speaking maid came forward and said that she appreciated having work through this service but that she felt enslaved because she had to do what other people told her to do.

When the hotel owner came forward to give her monologue, Steve Webster interrupted her to ask her questions. "What's your life like?" he asked. She said her life was pretty good. "What do you think their lives [the maids'] are like?" "Pretty difficult," she said, "because they have to work for other people and they probably don't get paid a whole lot."

"Would you invite one of these people over to your house?" he continued. She said, "Sure. Because you invite other people over so why shouldn't you invite them?" "If you invited an uneducated maid like Julie to come over and have dinner with you guys, would it affect your standing in society?" he asked. "I don't care what other people think," she said.

After the presentation, Steve said, "OK, what did you demonstrate today? In the past, what essential learnings were shown? In the present, what essential learnings were shown?" The students explained how both the characters in both the past and the present demonstrated "reluctance to share power," and "clear and concise communication," both of which were essential learnings for the assignment.

The students in the "audience" then competed focus questions on the group's performance:

1. How were the slaves of the ... society treated by their masters?
2. How did the ... society "view" these people?
3. What types or levels of slaves were there in the ... society?
4. What rights did these slaves have? What rights did these slaves lose?
5. How did the ... society enslave people?
6. How does the ... society's beliefs regarding slavery differ from what you know about slavery?
7. That essential learnings were evident in the group's society? (Justify your answer with specific examples).

Having been captivated by the performances, the students in the audience completed their focus questions in great detail, and then the next group got up to perform their tableau.

In giving the tableau performances, Steve's students synthesized their knowledge of slavery in different societies with their understanding of current social dynamics and demonstrated their learning creatively and effectively. These demonstrations were not something they could have easily done at the beginning of the school year—they needed the initiation into OBE premises, tenets, and goals and the practice in engaging in curriculum and demonstrating their learning to make this possible. At this stage, Steve did almost none of the talking; he sat with his sword and merely prompted the students to show him what they knew. The students had accepted control and responsibility for their learning.

Summary. It is apparent from these examples that transitional demonstrations of learning are dependent upon two factors: the student's capacity for giving demonstrations and the student's level of engagement in the curriculum. The student's capacity for giving demonstrations comes from frequent practice in doing so. The student's level of engagement in curriculum comes, as the previous section suggests, from a combination of a classroom environment which fosters high engagement and the initiation of the student into reflection on the purposes and goals of their learning. Both of these two factors are necessary; without one (or both), the demonstrations of learning will be "traditional" at best, as exemplified by Carl's, Patrick's, and Lisa's students. When these two factors are present, they combine in such a way as to enable students to take control of and be responsible for their own learning, and to meet the exit outcomes as well.

Self-Assessments

Carl, Patrick, Lisa, and Steve all had their students evaluate their own learning through three different types of assessment tools: rubrics, expanded opportunities, and student-led conferences. However, the use of the first two tools varied significantly in the classes. Students in Carl's, Patrick's, and Lisa's classes used these tools only in a superficial way, while Steve's students used the tools to conduct rigorous, meaningful self-assessments.

Rubrics. The students used two different kinds of rubrics to assess their demonstrations of learning: a "checklist rubric" and, in Steve's class, a "quality rubric." All of the classes used "checklist rubrics" at one point or another in the year. An example of a checklist rubric was the rubric used in the beginning of the year in Lisa's class when students designed their anti-discrimination buttons:

1. Cut round circles.
2. Draw a symbol.
3. Write a slogan.
4. Use color.

On one level, checklist rubrics such as this were used by the teachers to make sure that students completed the required components of an assignment. In Lisa's, Carl's, and Patrick's classes, this was the only type and the only manner in which rubrics were used. In Steve's class, the checklist rubric also became the focus of conversations after students had given presentations. As described in the example of their presentation of their favorite TV show or movie, when doing performances, Steve's students would say what their rubric was before they did their demonstration. Then, after the demonstration, the "audience" would give "suggestions for improvement" such as "They talked too fast. They need to slow down," or "They need to talk louder." "Was that part of their rubric?" Steve would ask. "Yes, they said 'speak clearly' as part of their rubric," a student would answer. In other words, the checklist rubrics were used by students to evaluate one another's performances, and to help students improve their demonstrations of learning.

In addition to differences in the manners in which rubrics were used, the extent to which the rubrics held the students accountable for their work also varied. For example, the rubric Lisa designed for the students' folktales read:

Trickster Folktale Rubric

1. Title
2. Perfect paragraph format
3. 1 animal/insect
4. 3 dumb animals/insects
5. A definite plan the trickster follows
6. Descriptive words used
7. Interesting story
8. No more than 2 spelling errors
9. State moral

The rubric, interesting because of its step-by-step checklist nature, is also noteworthy because of point 8: "no more than 2 spelling errors." This is indicative of the standard held in this class.

In contrast to Carl's, Patrick's, and Lisa's class, where the checklist rubric was the only rubric used, Steve and his students also developed a "Quality Rubric" which they used to evaluate all of their assignments. This rubric read:

> Rubric for Quality
>
> Assignment is neat and readable.
> All spelling is correct and has been checked with a dictionary.
> All grammar and punctuation is correct.
> Deadline for the assignment was met on or before time allowed.
> Name-date-subject-period and assignment were all clearly stated.
> All answers were justified and examples were given.
> The assignment was complete and did not "leave out" anything.
> Assignment went beyond what was required.
> Student put forth a "better than best" effort.
> Student followed directions.

The quality rubric demanded that the students go "beyond what was required" in terms of the assignment, grammar, and spelling and put forth a "better than best" effort. Steve used the quality rubric in a variety of ways. For example, when a student's work did not satisfy the quality rubric, he would give the students an expanded opportunity and write on the top of the page something akin to "Check your spelling. Use your quality rubric." Also, he would have the students check their own and their peers' work with the quality rubric.

Steve's students understood that quality work was demanded of them. "You have to try your best," said one student. "We have to try and go beyond our requirement if you want to get a quality paper," said another. "That's what we're mostly trying to study now, quality. Going beyond your requirement," said a third student.

Conversely, the following conversation ensued when one of Carl's and Patrick's students was asked about rubrics:

> *Interviewer:* *Can you clarify for me what a rubric is?*
>
> [No response]
>
> *Interviewer:* *Do your teachers explain to you what you need to do for an assignment for it to be done well?*
>
> Student: Oh, yeah, a little, but my teacher did that more last year.
>
> *Interviewer:* *Who did you have last year?*
>
> Student: Mr. Webster.

Interviewer: *Which was better, do you think—when Mr. Webster explained what you had to do or this year when your teachers explain it a little bit?*

Student: Last year.

Interviewer: *Why?*

Student: Because when you knew what you had to do, you learned more. It was easier.

Interviewer: *So which do you like better?*

Student: This year.

Interviewer: *Why this year?*

Student: Because it's easier.

Interviewer: *But you just said it was easier when you knew what you had to do, as in how it was last year.*

Student: Yeah, but this year it's easier because you don't have to work so hard to get it done.

In this conversation, the student said that he learned more when he used rubrics in Steve Webster's class, but liked it better this year when he doesn't have to work so hard to get the assignment completed. Even though the student knew he would learn more with the help of rubrics to guide a self-assessment process, the student was motivated by the prospect of "being done with it." In contrast, Steve's students knew that if their assignments were not "quality," they would receive an expanded opportunity and would do the assignment again.

Expanded opportunities. As hinted at in the above discussion, the use of expanded opportunities differed in the classes. In Carl's and Patrick's class, the term "expanded opportunity" was used when students were to revise their first draft of their book report and then turn in a second draft. No connection was made between expanded opportunities and rubrics, nor between expanded opportunities and the idea of quality. The students were all required to turn in a second draft, and this draft was labeled as an "expanded opportunity."

In Lisa's class, expanded opportunities were most often used in cases where students had not completed their assignments. The majority of students regularly failed to complete their homework assignments on time. Expanded opportunities were given to them so that they would do their homework. An example of Lisa's use of expanded opportunities came during the implementation of the Slavery unit described above. After the first group gave their presentation—which, as described above, was quite poor—Lisa said, "Well, since you guys went first, I'll give you a B+" She then asked them if they wanted an expanded opportunity for an A, and they said no, they'd keep the grade. The B+ they received had nothing to do with the quality of their demonstration. And because a B+ was seen as being a good enough grade, the students had no reason to want an expanded opportunity.

Occasionally in Lisa's class, expanded opportunities were given to students to improve the quality of their assignments. Once their assignments had been "done," expanded opportunities were given the students to improve them—to improve the elements listed on the rubric, such as spelling, punctuation, grammar, and essay content. Yet the students did not improve their work in a systematic way. During a classroom observation, the students went up to Lisa again and again with their work to get it approved. Lisa would quickly read the paragraph and respond, "I want you to describe more. I want you to make a good story." Students lined up with their work, only to be turned away to do it again and again. The students did not have a solid sense of "quality"; instead of individually or with a peer using a rubric such as Steve's Quality Rubric and evaluating their own work, they kept coming up to Lisa with their work until she said it was OK.

Steve's use of expanded opportunities was more rigorous. If an assignment failed to meet the requirements, or if he thought the students could have *gone farther beyond the requirements,* he would *tell* them that he was giving them a second chance to improve. In this sense, the expanded opportunity was mandated.

However, as discussed earlier, if the students failed to meet their requirements because they had not managed their time well, Steve refused to give them an expanded opportunity. This policy established a effective motivation for students to both get their work done and to do it well. During class, Steve would ask the students, "Is an expanded opportunity a punishment?" and the students would respond in unison, "No!! It will *help us!!*" Steve's students were asked if they liked having expanded opportunities, and the following discussion evolved:

Interviewer: *Do you like the idea of having an expanded opportunity and second chances?*

All: Yeah.

Student D: Some people don't though and I don't understand why because, I mean, if they don't like it, if they get something wrong, they'd get an expanded opportunity. So I don't understand why they don't like it.

Student B: Like some kids don't like the idea of the expanded opportunity because they like have to do the work over and over and they get mad and they say "I hate this" because they have to do it over and over.

Interviewer: *Until it's quality.*

Student D: Yeah, quality work, that's what we have to do. Another reason why some people don't like it is because [they think] they do good work on the first try. But they don't really know better. They don't really know what they could do. So then, that's what happens.

Steve's students saw expanded opportunities as opportunities to not only correct things that they had done wrong but to explore how well they could do an assignment. They knew that quality work was what they "had to do."

Student-led conferences. The final form of assessment used was the student-led conference. Although the degree of reflection practiced on a daily level varied in the classes, by using student-led conferences, students school-wide had the opportunity to take a different look at their learning and how well they were meeting the exit outcomes.

For the student-led conferences, students made use of their portfolios of their work. The students' portfolios varied in terms of how many assignments the students had, how neat they were, how sophisticated the assignments were, and what grades the students had received on the assignments. But all of the students wrote a note in front of each assignment saying why they were including the work in their portfolio and what strengths and weaknesses they demonstrated through the work. In addition, all of the students' portfolios included an essay on how they had met the exit outcomes.

After the students discussed their academics, shared their portfolio materials, spoke about how they were meeting the exit outcomes, and gave their reflections on their work, the teachers and parents had an opportunity to speak and ask students about specific assignments, or about their tendencies to turn things in late, or their habit of turning in assignments without checking the writing for spelling errors. In all of the conferences witnessed, the students responded to the teachers' and parents' questions frankly, saying that they knew they needed to improve on specific things. One student from Lisa's class who had not turned in a lot of assignments told his mother that it would help him if she sat down with him while he did his homework. This strategy appeared to pay off because on a later visit, he was one of the four students who had done the newspaper assignment described in the "Occasional engagement in the curriculum" section above.

Many parents expressed surprise and pleasure in seeing their children take on the role of explaining their learning. On the bulletin board in the teachers' lounge, the teachers compiled a list of comments they heard from parents during the student-led conferences. The comments included:

> **"I like kids to evaluate themselves."**
> **"It's good for kids to point out their strengths and weaknesses."**
> **"Very futuristic; great for interview skills."**
> **"Helps students feel more responsible."**
> **"This has opened up doors between my son and I."**
> **"Taught my son the importance of organizing material to present to me."**
> **"Positive event."**
> **"Kids can't hide anything."**
> **"Good experience!"**
> **"In our culture people are very shy ... This process helps us share ... People here talk a lot."**
> **"Good communication."**
> **"Better than teacher-parent conference."**
> **"Got a good idea of all subject areas."**
> **"I love how you all do this stuff!"**
> **"Got to know my own kid's needs."**
> **"Kids are truthful."**

> "I wish we would've done this when I was a kid."

The culminating activity of the student-led conference was that the parent wrote a reflection letter back to the student. The end of one of these letters from a parent of a student in Carl's and Patrick's class read, "I'm pleased to see your extra effort in being responsible for doing your work, caring about your grades and being very organized. I love you."

Carl and Patrick also had their students write an evaluation of their own student led conference. One of these read:

> **My conference went well because:**
>
> "My mom understood and she agreed with me on some things and always knew how I felt and explained things to me and I explained things to her that she never even knew."
>
> **The best part about my conference was:**
>
> "Talking to my mom and explaining all my work to her and she was pleased with some of the work and not so pleased with other work otherwise my conference went great."
>
> **One of the difficult things about my conference was:**
>
> "Explaining to my mom all the low grades and tardies and explaining her some of the work in which she didn't understand and it was kind of hard to explain some of the work."
>
> **For my next conference, I need to remember to:**
>
> "Study my lines and try to explain more things to her in which a way she understands what I am doing and it will be a lot easier for both of us."
>
> **I forgot to tell/explain to my parents about:**
>
> "I forgot to tell my mom to withhold her questions until after I had explained all of my work. I also forgot to introduce my mom to Mr. Wykoff."
>
> **One of the positive things that I feel that I have learned during the conference process was:**
>
> "I can learn to communicate with my mom and there is nothing which I can hide from my mom we can just sit down have a discussion about what's on my mind."
>
> **One of the positive things that I feel that my parents/guardians learned about me was:**
>
> "I have matured very much and that I used very big words and that I can also hold much responsibilities as the conference and take over and tell them all that I know and learn at school."

This final comment, that the student believed his parents learned that he has matured and can hold responsibilities, speaks again to the effect that reflective practices can have on students' conceptual understanding of their learning *and* their degree of ownership of their learning.

Summary. The above examples suggest that if students have opportunities for reflection and performing meaningful self-assessments, their degree of control and responsibility for their learning will rise. While the changes in attitudes and behaviors noted in Carl's, Patrick's, and Lisa's students as a result of student-led conferences are impressive, more significant changes would have been possible if their engagement in reflection and self-assessment had been consistent.

Steve Webster's students experienced this consistency. As shown in his class, assessment was key not just at the end of an assignment, but along every step of the process. At the beginning of the school year, students were taught to assess what was important to be learned overall through their exposure to exit outcomes and their assignments related to the exit outcomes. Then, within the curriculum units, they were taught to assess what was important for a particular assignment through their initiation to the essential learnings. The students were also taught to assess what was needed to complete a particular assignment by learning how to develop and use rubrics. They were taught to demonstrate their learning and then assess what was demonstrated through peer- and self-assessments. Finally, they were taught to see expanded opportunities as a opportunity for improving their demonstrations, to assess where to go next.

In other words, Steve Webster's students were taught to see the connections between their self-assessments, their demonstrations, their engagement in curriculum, and the premises, tenets, and goals of OBE. They were taught to see these connections because Steve was able to see these connections himself. Steve's and his students' abilities to conceptualize teaching and learning in the OBE context were key to their implementation of the philosophy. In the next section, we pursue this line of analysis further.

III. CONTEXT OF CHANGE

The principal of Oakgrove Middle School first introduced teachers to Outcome-Based Education in 1990. Since then, the teachers and students have come a long way in their implementation of the philosophy. The principal is proud of pointing out that since the philosophy has been implemented, students have in fact been getting higher grades. In the first semester of the 1991-92 school year, 8% of the students in the school received A's, growing to 14% by the second semester, 21% by the first semester of the 1992-93 school year, and 28% by the second semester. Meanwhile, the percentage of students receiving F's went from 19% in the Fall of 1991 to 4% in the Spring of 1993.

While the principal is pleased that more students are getting higher grades, he asserts that higher grades are not the final goal of the OBE program at Oakgrove. He also wants to see students deeply engaged in learning, putting their learning to sophisticated use, and evaluating their own learning.

As we saw in the three history classes, only one class of students met the principal's vision. Three factors appear to influence the implementation of OBE at the classroom level:

- teachers' conceptualization of teaching in the OBE context
- students' conceptualization of learning in the OBE context
- teachers' understanding of the new curriculum

Each of these factors is important for the school to consider as it evaluates how to move forward toward enabling more students to realize the goals of the OBE philosophy.

Teachers' Conceptualization of Teaching in the OBE Context

For both teachers and students, working within an OBE context requires being able to understand how the philosophy connects with the "conditions that schools control": the design and organization of curriculum, the emphasis of instruction and what students learn, and how the students' learning is assessed and the time given for learning. For teachers, the challenge is to see the connections as depicted in Figure 1. Talking through the figure by beginning at the center of it, teachers need to be very familiar with the components of the reform: the premises, tenets, and goals of Outcome-Based Education. They then need to be able to see how the curriculum can be designed and organized based on the OBE principles, and how their instruction can enable students to make use of the curriculum in such a way as to meet the exit outcomes. Furthermore, the teachers need to be able to see how assessment strategies can be used to help students determine the quality of their own work and whether or not they had met the exit outcomes.

Thus far, we have traced the arrows that lead both out of the center of the figure and into the center of the figure. The arrows are designed as such because in the OBE context, the premises, tenets, and goals serve as both the *cause* and *consequence* of the focal points in the classroom;

the OBE philosophy *guides* the design of curriculum, instruction, and assessment, and, simultaneously, provides the *goal* of the implementation of curriculum, instruction, and assessment practices: for students to meet the exit outcomes.

There are double-sided arrows between the curriculum, instruction, and assessment categories as well. These arrows depict the interconnection between the conditions schools control, and the strengthening of each component that occurs through attention to a companion component. Ideally. the curriculum will be designed and organized in such a way as to make obvious that the emphasis of instruction is to help student demonstrate and make use of their learning, and to suggest that assessment tools be taught to students to evaluate their demonstrations. Here, the movement is from the "design and organization of curriculum" category outward to the two other components. However, the arrows go outward from the other components as well. For students to be capable of more than traditional demonstrations, teachers need to design and organize the curriculum to support them being independent, creative thinkers, and assessment strategies need to be designed so that they have control and responsibility for their learning. The arrows also move outward from the assessment category: if students are to be the evaluators of their own work, teachers must design the curriculum and the emphasis of their instruction so that students know *all along the way* what they are shooting for.

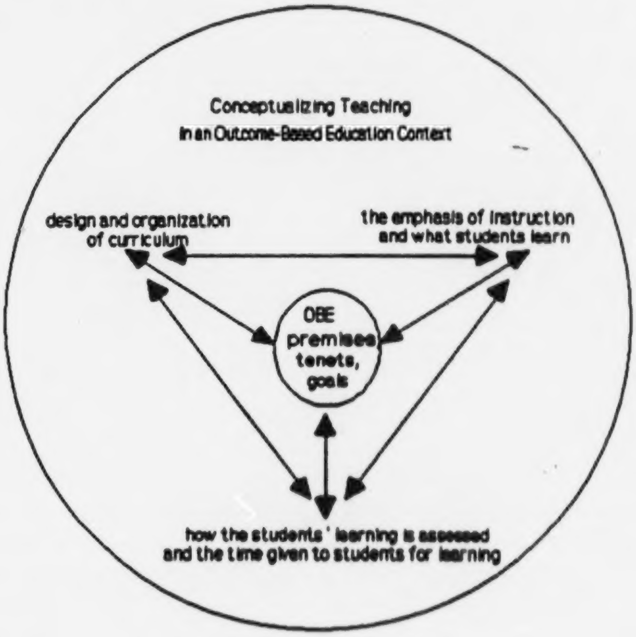
Conceptualizing Teaching
in an Outcome-Based Education Context
design and organization of curriculum
the emphasis of instruction and what students learn
OBE premises tenets, goals
how the students' learning is assessed and the time given to students for learning

Figure 1

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At a certain level, managing these "conditions that schools control" means giving up control. The curriculum needs to be designed with room for student initiative, the emphasis of instruction needs to be organized so that students use that initiative in demonstrating their learning, and the assessment strategies need to be directed by the students. These are major shifts from traditional teaching practices, shifts which take a good deal of time and require enormous support.

Of the four teachers participating in this case study, only Steve Webster was able to see the implications that the OBE philosophy had for each of the components and the strengthening that could occur by making all the components cohere with one another. Steve, a young teacher, often said that the premises, tenets, and goals of OBE made complete sense to him. He said that even before he was introduced to the OBE philosophy, he believed in designing his coursework so that students would "show what they know" and evaluate their own learning. For Steve, the OBE philosophy brought all of his previous beliefs into greater focus: with OBE, he found a way to coordinate his curriculum, instruction, and assessment practices.

At the other extreme, Patrick Wykoff and Carl Larsen were older, more experienced teachers who had taught in "traditional ways" for years prior to joining the staff at Oakgrove Middle School. Though the philosophy intrigued them, Patrick and Carl were "not sure how it works." Lisa Dallins expressed the same confusion. Although she was a young, innovative teacher, Lisa did not have the same natural bent toward the philosophy that Steve had. Patrick, Carl, and Lisa had much more difficulty than Steve did in seeing the connections depicted in Figure 1.

Separate interviews with Steve and Carl regarding the design of the new history curriculum were telling. Both teachers were asked how central the OBE principles were in the design of the history units. Steve's reply was:

> We designed the units and made sure that we designed down from the OBE principles. If we didn't, then we would just be making up regular content area units. So the focus was the OBE. So it played a major part in designing our units. We're still intending to go back and make sure that the outcomes are defined and clear. We do not want to have the OBE sprinkled on.

In contrast, Carl's reply was:

> OBE played some part. I tried to give it as big a role as I possibly could ... OBE kind of dances around in these units, but it has no firm footing. Now why is that? I don't know. Maybe because ... like for myself ... myself I don't have a full understanding of OBE.

Patrick and Lisa concurred with Carl. They all felt that they needed to see "more examples of how OBE works."

Although Patrick, Lisa, and Carl had attended the same number of inservices on OBE as Steve, they very clearly needed more tangible explanations of how OBE could be implemented. Given that within their own midst they had a teacher who was very conversant with the OBE philosophy and the implications the philosophy had for teaching practices, they would do well to have more frequent conversations with Steve, and perhaps even sit in on his classroom and watch what he was doing.

Oakgrove's course schedule allows for this kind of flexibility: the family structure allows teachers to team teach, or to free one another from a period of teaching so that they might go to other classes and watch teachers teach, and Wednesday afternoons are available to teachers for conversations. By increasing their discussions, and, hence, their conceptual understanding, of how to bring the OBE philosophy and "the conditions that schools control" into greater coherence, the teachers at Oakgrove can grow toward a more even implementation of the philosophy than currently exists.

Students' Conceptualization of Learning in the OBE Context

Like teachers, students need to be able to see the connections between their engagement in curriculum, their demonstrations of learning, their assessments of learning, and the premises, tenets, and goals of Outcome-Based Education [see Figure 2].

Ideally, students who have a deep understanding of the premises, tenets, and goals of OBE will understand that engagement in curriculum is vital to their development as individuals who embody the exit outcomes. With their understanding of the importance and value of their schooling, and with a conducive classroom environment, students will take control of and responsibility for their learning, which they will demonstrate through performances that reveal both conceptual understandings and application to their own lives. Furthermore, they will be capable of assessing their own learning, determining whether or not they had completed quality work or met the exit outcomes. They will, in addition, be responsible for requesting "expanded opportunities" in order to reach their goals if they had not done so already.

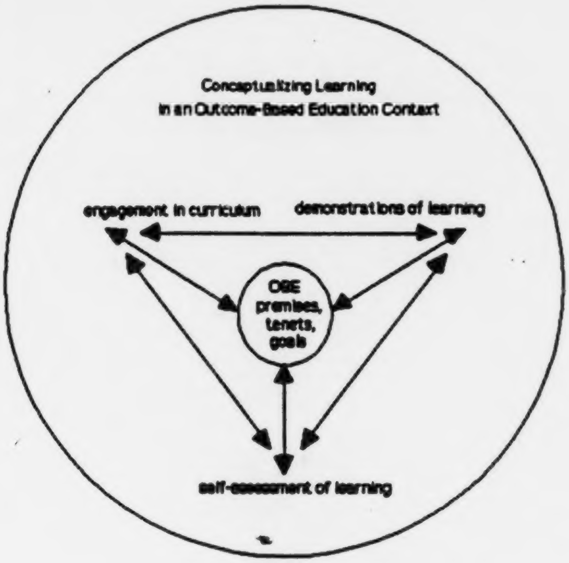
Conceptualizing Learning
in an Outcome-Based Education Context
engagement in curriculum
demonstrations of learning
OBE premises, tenets, goals
self-assessment of learning

Figure 2

It is no coincidence that the students at Oakgrove Middle School who engaged in their curriculum deeply, who demonstrated their learning in sophisticated ways, who regularly assessed their own learning, and who were not satisfied until they had successfully reached the exit outcomes were students in Steve Webster's class. With his own sophisticated understanding of how OBE interacted with the components in the classroom, he was able to train students in the OBE philosophy and provide an environment in which students could initiate, control, and be responsible for their own learning.

In contrast, the students in Carl's and Patrick's class had almost no understanding of the OBE philosophy, and the activities and demonstrations in which they were engaged were of the teacher's design, not the students'. In Lisa's class, the students were given many opportunities to take control and responsibility for their learning, but they had not been taught how to do so. A palpable dissonance arose between Lisa's goals and the students' abilities. While Lisa wished for the students to take control of their learning, the students simply could not digest and then make use of information in creative ways, they could not support their interpretations of a situation with researched facts, they could not determine for themselves the quality of their work.

What Steve's students had and Carl's, Patrick's, and Lisa's students needed were consistent opportunities for reflection so that they could build a conceptual understanding of what learning meant in an OBE context. The student-led conferences provided one opportunity for this kind of reflection. It allowed the opportunity to step back, look at their work, reflect on the exit outcomes, and determine in what ways they were or were not meeting them. The effectiveness of the student-led conferences show that *all* students are capable of meaningful reflection on their learning. Moreover, it shows the potential that consistently incorporating reflective capacities and opportunities for students could have in their engagement and demonstrations of learning.

Teachers' Understandings of the New Curriculum

The third factor which influenced the implementation of OBE in these three history classes was the fact that the history units were very new. The Spring semester of the year during which this study was conducted was the first time the new history units were implemented. Because different teachers wrote different units, the teachers were not always familiar with the units they were implementing. And, even with units they had designed themselves, this was their first experience using these materials with students. Given these conditions, it is quite understandable that the implementation of the materials did not always go as envisioned.

In addition, the materials were written very quickly over a period of four months, and, consequently, needed some fine tuning. As pointed out by one of the professors who reviewed the units for their historical accuracy, the units did well to " 'que' students' experiential experiences to topics that relate to their lives" but seemed to be weak on historical content. The professor's suggestion was to find a way to "establish past-present similarities [but] not lose sight of the history they are studying."

Throughout the units, the professor made notations about content and topics that appeared to be missing: mention of black soldiers and Abigail Adams in the Revolutionary War Unit; mention of the Southern view of blacks and slavery, abolitionist literature, the Dred Scott Case of 1856-57, slavery as an issue that divided the nation, the Compromise of 1850, the Kansas-Nebraska Act of 1854, and the birth of the Republican Party in the Slavery Unit; substantial mention of the events between 1861-1865 for the Civil War Unit; discussion of Lincoln, Black Codes, the Jim Crow laws, black's voting rights, and lynchings in the Reconstruction Unit.

The professor's suggestions serve to point out that there were academic issues within the curriculum to which the teachers needed to pay acute attention. But there is another important element to the professor's suggestions: for every individual, event, and issue that the professor recommended to be included in the units, there are many others that could be included. Current literature on history curriculum reform takes the view that an account of an historical event or time period is inherently "incomplete," there are always additional aspects that can be considered. Instead of recounting the facts from the past, many historians and students in history are beginning to ask question such as "What's missing?", "Who's missing?", and "Where did this information come from?" Historians and students then conduct research based on these questions.

Encouraging independent student research of this kind would push students even further toward becoming effective communicators, inspired learners, productive workers, responsible citizens, and resourceful thinkers—that is, meeting the exit outcomes. Moreover, encouraging the students to ask questions of the curriculum and to research answers to their questions may help the curriculum become more "transformational." The curriculum as it is currently written encourages students to give "transitional" demonstrations, where they analyze concepts and their interrelations; propose solutions to multi-faceted problems; use complex arrays of data and information to make decisions, plan complex structures, processes and events; and communicate effectively with public audiences.[16] But if students are to apply their learning in real-life performance contexts, as transformational demonstrations of learning require, alterations in the curriculum that provide for even greater student initiative need to be made. Students need to have the opportunities (and encouragement) to consider the implications of their learning and research for the society around them, and then extend their learning through service to society.

Summary. Teachers and students at Oakgrove Middle School need time and support in order to be able to come to a holistic conceptual understanding of the implications the OBE philosophy has for teaching and learning. When they come to this understanding, it will be easier to see how specific components—such as the curriculum—can be revised even further to enable students to reach transformational demonstrations of their learning.

A closing point about Figures 1 and 2 is needed: the relationships between the curriculum, instruction, assessment, and OBE is depicted within a circle because with each cycle of working within this context (whether a cycle means implementing a unit or implementing a year-long course), the links between the different components will become clearer, and each component will feed the next component. Teaching and learning within an OBE context is an evolutionary process; because it involves a shift from typical teaching and learning practices, it requires trials and errors, out of which deeper understandings will build. As the errors become fewer, the "success stories" will occur more often. And, if the premises of OBE are true—and we have examples from Steve Webster's class which lead us to believe that they are—those success stories will breed more success.

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[16] Spady, p.20.

IV. CONCLUSIONS AND IMPLICATIONS

What does this look into the classroom tell us about reform efforts in situations where a school has adopted a particular philosophy in order to facilitate change?

The successes experienced in Steve Webster's classroom and the "areas for improvement" found in Carl Larsen's, Patrick Wykoff's, and Lisa Dallins's classroom suggest four points that educators embarking on reform efforts might wish to consider:

- the power of implementing a guiding philosophy which serves as the cause and consequence of teaching and learning
- the importance of teachers achieving a solid conceptual understanding of the philosophy
- the importance of students achieving a solid conceptual understanding of the philosophy
- the importance of a teaching environment that coheres with the tenets of the philosophy

For those attempting to realize change in their schools, hopefully attention to these four points will make the process, undoubtedly challenging, a bit easier.

The Power of Implementing a Guiding Philosophy which Serves as the Cause and Consequence of Teaching and Learning

Outcome-Based Education, as the teachers at Oakgrove Middle School are attempting to implement it, serves as both the grounding and goal of what goes on in the classroom. The philosophy provides teachers with guidelines for designing and organizing a curriculum, determining the emphasis of instruction and what students learn, and designing tools for assessment. At the same time, the philosophy gives teachers a goal to shoot for: student achievement of the exit outcomes.

Similar statements can be made for students. For them, the philosophy provides a basis for engaging in the curriculum, demonstrating their learning, and assessing their learning. Simultaneously, the philosophy gives them an end goal to shoot for: the achievement of the exit outcomes.

The examples from Steve Webster's classroom show that with a central philosophy such as OBE, teachers and students can work together on curriculum, demonstrations, and assessments to meet their common goal.

In other schools and districts, the guiding philosophy may not have to be OBE to achieve similar results. But whatever the philosophy is, teaching and learning practices need to be tightly linked to it, and teachers and students need to have a solid conceptual understanding of what teaching and learning means in the context of the philosophy.

The Importance of Teachers Achieving a Solid Conceptual Understanding of the Philosophy

This case study shows that, given their individual backgrounds and experiences in teaching, teachers approach the implementation of a new philosophy in different ways. Some teachers like Steve Webster may find the philosophy to be in keeping with their prior practices and consequently will be able to see direct connections between the philosophy and their teaching practices.

Other teachers may be more like Lisa Dallins, Carl Larsen, and Patrick Wykoff and may have more difficulties seeing the connections between the philosophy and teaching practices. They may want to "see how it works" before trying to implement the philosophy themselves.

Both types of teachers need ongoing opportunities for learning about the philosophy and the implementation of the philosophy. They need to be in consistent communication with others who are attempting the same task, and need opportunities to step back and assess their own learning, their demonstrations of learning, their strengths, and their "areas for improvement."

By building their own reflective practices, they will develop deeper conceptual understandings of how "the conditions schools control" can be interwoven with their overarching philosophy.

The Importance of Students Achieving a Solid Conceptual Understanding of the Philosophy

This study also shows that by providing students with an understanding of the philosophy, tools to make use of that understanding, and a classroom environment wherein to use their tools, students become capable of taking a high degree control of and responsibility for their own learning.

The learnings from this case study parallel those from Baird and Mitchell's study with five high school classes in Melbourne, Australia. In their study, students were "trained" in skills of metacognition, "the knowledge, monitoring, and control of one's own learning."[17] As a result of this training, Baird and Mitchell found that "students started to accept more responsibility for their learning and became more informed about lesson nature and activities. They became more able to take some control of their learning. The study led to improved attitudes, behaviors, and performance."[18]

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[17] J.R. Baird and Ian J. Mitchell, ed., *Improving the Quality and Teaching of Learning: An Australian Case Study—The PEEL Project* (Melbourne, Australia: Monash University Printery, 1993), p.10.

[18] Baird and Mitchell, p.11.

Although Steve Webster did not define what he did with his students as "training in metacognition," in effect, this is what Steve did. By providing his students with an initiation on the premises, tenets, and goals of Outcome-Based Education at the very beginning of the year, Steve enabled his students to develop a conceptual understanding of their learning and the purpose of their learning.

Educators considering implementing a new philosophy with students might set aside a week or two at the beginning of the year for initial "training" on the philosophy. This training may mean sacrificing other beginning-of-the-year activities, but the sacrifice will be made up for by high degrees of engagement in curriculum, demonstration of learning, and assessment of learning throughout the school year.

The Importance of a Teaching Environment that Coheres with the Philosophy

This case study dwelled very little on considerations of the teaching context at Oakgrove Middle School. This is because there were rarely any mentions of dissatisfaction with the environment—teachers felt supported by the school and district administration, as well as by the community. What is more, teachers had opportunities to collaborate and support one another. Their course schedule provided them with time during the week to plan with their team members and to consult with the other teachers in their family.

Oakgrove Middle School is impressive in the respect that the teaching environment was as important to the school administration as the learning environment. The principal wanted to be sure that the teachers had the opportunities that they were hoping to give students—opportunities for ownership, self-direction, and self-assessment.

Those implementing new philosophies at schools may want to consider whether the teachers have as many opportunities for developing understanding of their teaching as they may be trying to provide students for their learning. If not, educators may want to look at the underlying, and sometimes hidden, contextual factors that could be adjusted to provide teachers with these opportunities.

Closing

It is impossible to predict what other implications this case study may have for all the educators, policy makers, and legislators who read it. Working from the assumption that "most people are capable of better learning than they currently demonstrate, and that improvement in learning is possible, individually and socially desirable, and indeed necessary,"[19] we in education have our work cut out for us. This case study has attempted to describe how improvement of learning can be possible through the implementation of a philosophy that provides students and teachers both with a deep conceptual understanding of what teaching and learning means and with a common goal. We hope that the ideas here spark chords within readers and that the success stories inspire readers to pursue their own paths beyond the ones recommended here.

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[19] J.R. Baird, "Improving Learning through Enhanced Metacognition: A Classroom Study," *European Journal of Science Education*, 1986, Volume 8, Number 3, p.263.

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APPENDIX A
OAKGROVE'S "BELIEF STATEMENTS"

WHAT WE KNOW

Students learn at different rates and in different ways
Direct teacher intervention helps students succeed
Many students feel insecure, very little structure in their lives
Clear focus on desired outcomes increases success
Students will make mistakes
Students need to be held accountable for their actions
Students come with different backgrounds and perspectives
Students will meet high expectations
Students want respect
Students want honest answers
All students need guidance, support, and stability
Unstable family situations create pressure on students
Our population is extremely mobile ... families change jobs, homes, and communities much more frequently now than in the past
New technology has changed the way we live
Knowledge is doubling every few months
Increasing emphasis in health and wellness
The population of the U.S. ... is increasing diverse
Increasing international interdependence
All students want to contribute and feel accepted

WE BELIEVE

All students can learn and succeed but not on the same day
Success breed success
Schools provide opportunities for success
All students need compassion
All students need guidance
All students learn at different rates and in different ways ... and that is OK
All students need to belong
All students need approval (peer and adult)
All students are important
All students need positive role models
All students have the ability to change
All students need to laugh
All students need love and praise
All kids need to learn how to care about themselves and others
All students are young people and should be allowed the opportunity to grow, learn, and feel
We make a difference
All students need to learn responsibility and be accountable for their actions
All students need to feel safe

WE WANT ALL KIDS

To acquire and maintain a positive self image
To be successful
To be responsible for their choices and actions
To care and respect themselves and others around them
To get along harmoniously with their environment

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To be proficient in all communication skills; verbal/written
To be positive contributors to our multicultural society and world
To be quality producers
To be inspired and life-long learners
To be perceptive thinkers
To be flexible leaders
To be visionary citizens
To strive for life-long wellness

WHAT WE DO

Establish clear outcomes
Model expected behavior
Provide relevant instruction
Align demonstrations/assessments to what is taught
Provide an environment conducive to learning
Let students know what is expected
Provide timely and specific feedback
Provide for individual differences
Provide expanded opportunities
Evaluate students on what is expected
Give credit when credit is earned
Try always to remember that the teacher-student relationship extends beyond the mere translation of knowledge and touches the hearts and minds of growing young people
Provide opportunities for student self-evaluation

APPENDIX B
PARENT AND COMMUNITY INVOLVEMENT WITH OBE

1. Have a clear vision of your plan.
2. Include key parent leaders in your planning.
3. Teachers/Staff members are vehicles for the distribution of information, so make sure that they are informed (knowledgeable).
4. Introduce concept to a small group of parents (School Site Council, PTA Board, etc.). Use this as your practice session.
5. Allow teachers to introduce some points to parents on an informal basis such as a parent conference.
6. Briefly describe the planning process in your newsletter/school publications.
7. Hold a general meeting for parents. Make sure parents have ample notice for meeting and that the invitation has been mailed (ensure the delivery).
8. Hold "coffee clatches" and/or informal small group meeting to introduce change.
9. Invite parents to visit the classrooms on a regular basis.
10. Involve, if possible, area business people, in gathering data for what the business world would like to see in your Exit Outcomes.
11. Invite the press (newspaper) to write articles about the possible upcoming change.
12. Make sure that all presentations are delivered in a clear, concise manner.
13. Validate the concerns from those that might be opposed to this change. Listening to their concerns helps to relieve their anxieties.

APPENDIX C
STATE HISTORY FRAMEWORK

7th Grade: World History

1st QUARTER:
1. Uncovering the Remote Past
2. The Fall of Rome
3. The Growth of Islam

2nd QUARTER:
4. African States in the Middle Ages and Early Modern Times
5. Civilizations of the Americas
6. China

3rd QUARTER:
7. Japan
8. Medieval Societies: Europe and Japan
9. Europe during the Renaissance, the Reformation, and the Scientific Revolution (Part 1)

4th QUARTER:
10. Europe during the Renaissance, the Reformation, and the Scientific Revolution (Part 2)
11. Early Modern Europe: The Age of Exploration to the Enlightenment
12. Linking Past to Present

8th Grade: U.S. History

1st QUARTER:
1. American Revolution
2. Forms of Government Prior to the Constitution
3. U.S. Constitution

2nd QUARTER:
3. U.S. Constitution (continued)
4. Launching the Ship of State

3rd QUARTER:
5. Divergent Paths of American People
6. Toward a More Perfect Union

4th QUARTER:
7. Rise of Industrial America
8. United States Emergence as a World Power

APPENDIX D
COURSE OUTLINE AND COMPONENTS OF THE CORRELATING STATE HISTORY FRAMEWORK

COURSES AND TOPICS	CORRELATING STATE HISTORY FRAMEWORK
Power and Instability	
Conflict and Resolution	American Revolution
War and Peace	African States
Issues of Strife	Divergent Paths of American People
	Towards a More Perfect Union
Human Migration	
Discovery	The Age of Exploration
Exploration	Colonial Period
Transportation	Westward Movement
Epidemics	Rise of Industrial America
Beliefs and Organizations	
Rights and Responsibilities	Religions
Racism and Equality	Reformation
Major Religious Movements	U.S. Constitution
Human Expression	
Arts	Feudal Period
Technology and Invention	Renaissance
Literature	Technological Evolution

APPENDIX E
CLASSROOM POSTER

WHAT THE HECK IS OBE?

OBE

- deals with real life roles and skills
- says that students are capable of evaluating their own and other's work
- says that all students can succeed
- believes in high expectations for *all* students
- encourages students to take on significant roles and responsibilities in their community and world
- measures what students can "do and be like"—not just what they know
- makes students accountable for their own learning, actions, and choices

CASE STUDY OF ROCKVIEW HIGH SCHOOL: THINKING ACROSS DISCIPLINES

BEVERLY ANDERSON PARSONS
CURRICULUM REFORM PROJECT
UNIVERSITY OF COLORADO

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This paper was prepared for the Curriculum Reform Project, a study of curriculum change in mathematics, science and critical thinking which is funded by a grant from the U.S. Department of Education's Office of Educational Research and Improvement (OERI Grant #R91182001). The opinions expressed herein are those of the author and the participants in this study.

FOREWORD

When faced with a challenge, a detailed story of someone else's experience in a similar situation generally is of strong interest. In reading someone else's story--be it political history, a chronicle of dealing with a family tragedy, or the story of a major business success--we do not expect to find a formula to apply directly to our own situation; instead we hope to find insight and inspiration. Thus, the story contained in this report should be engaging to individuals committed to educational reform in a local school context. It is the story of one school--or department within a school--engaged in fundamental reform of education for its students.

Similarly, one should not expect to find in this case a model for a specific educational reform to initiate in another locality. Every context is different. Each local school and community culture has its distinctions, each individual's and group's educational goals have different shadings, each setting has its own history, and each school has unique constraints to making change.

Not only does one formula not fit all schools, there is no specific formula for a given school. A central message of our case studies is that educational reform is a long-term process for which there is no detailed road map. It is an uneven process with highs and lows, failures and successes, but gradual movement toward greater and more profound learning for students.

What we can expect to find in this story are insights about new teacher roles, how students go about learning with greater depth of understanding, the context in which such shifts can occur, the challenges that must be overcome to initiate these changes, and actions taken by various parties to keep the process of change moving forward. Reflecting on someone else's story can be helpful in the process of developing one's own plans, collaborating with others to move the process forward, and helping students take responsibility for learning.

The Research Project. The case study reported here is one of nine--three each in science, mathematics and higher order thinking across the disciplines--conducted as part of the Curriculum Reform Project. The cases were studies of individual schools--actually a department within a school in the case of science and mathematics--in the process of solidifying reform. Each was selected because it was a successful example of reform. A researcher spent 20 or more days at the site to learn what changes they were making, the barriers encountered, how they overcame these challenges, the nature of their successes and their hopes for the future.

Site Selection Criteria. Sites were sought which had initiated reforms consistent with those recommended by leading groups in the respective field, e.g., the Curriculum and Evaluation Standards for School Mathematics (Commission on Teaching Standards for School Mathematics). Final selections were based on program outcomes including student test scores, enrollments in subsequent elective courses in the given subject area, and professional judgments about the quality of the curriculum provided to students.

Site Selection Process. The search process began with the solicitation of nominations from researchers and knowledgeable practitioners across the U.S. Key people at the nominated schools were contacted by phone to get additional information and written exchange of information followed. Selection according to the above criteria resulted in schools spread across the country with considerable variation in location (e.g., urban vs. rural), economic level and ethnic makeup of the communities.

Research Methodology. In each case the researcher was immersed in the activities of the school and collected a wide range of information. Data included classroom observations, interviews with students, teachers and administrators, and a variety of documents from the site. The voluminous field notes and interview transcripts were analyzed and an interpretative report written.

Cross-site Analysis. A cross-site analysis of the nine cases was conducted to gain perspectives that extend across the sites. An individual case is rich in description and context but does not contain the depth of analysis that can come from looking across a number of cases. Thus, the reader is referred to the Project's cross-site analysis. Main points from this analysis to bear in mind while reading this one case, however, include the following:

- The reforms being sought are profound and demand major changes in teacher and student roles.
- The process for achieving such reforms is complex and demands a long period of time to attain.
- The schools in these cases have traveled a considerable distance on the road to reform but have not yet "arrived."

These cases are presented largely--though not exclusively--from the perspective of the teachers at the center of the cases. This perspective reflects the nature of the reforms and the way they have been initiated in each school. This perspective may be particularly important for initiating change. Our cross-site analysis shows that changes in teachers' values and beliefs--not just greater teaching skills and techniques--are central to reform. While changes in student roles and student work are the ultimate "bottom line," these teacher changes are an important intervening step.

We hope your reading of this case stimulates both interest and significant reflection about reform activities in your school.

Ronald D. Anderson
Director, Curriculum Reform Project
University of Colorado

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I. INTRODUCTION

Rockview High School: Founded in a Philosophy of Reform

In August, 1988, Rockview High School opened its doors to over 850 10th through 12th graders, 18% of whom were non-Caucasian, mostly Hispanic. Located in a lower to middle class neighborhood, the high school has had thousands of visitors who have come to witness its reform efforts.

Rockview High School was created in order to ease the crowding of students in the district's two other high schools. Taking advantage of the opportunity to establish a new high school with a different orientation to teaching, the district superintendent facilitated the creation of a reform-oriented school. His initial step in this direction was to hire a principal from outside the district who he knew to be a forward thinking, innovative person. He gave her as much freedom as possible within the boundaries of a fairly traditional district. This report provides a picture of the reform process that ensued.

Selection of Site

In selecting a site that focused on thinking across disciplines as an approach to reform, we were looking for a site that took a systemic change perspective in the sense that they were looking at fundamental change in the content and methodology of teaching and learning.

There are many ways in which schools and communities approach reform, some are associated with national reform efforts such as the Coalition of Essential Schools, viewed by many as the largest national reform effort for whole school change that emphasizes higher thinking for students. Some schools have associated themselves with efforts such as the High Success Network, a national network that is primarily focused on the concept of outcomes and standards based education, a major philosophy embedded in much of today's reform.

Other schools have chosen to develop an eclectic, self-determined strategy of reform (since many schools prefer to draw ideas from multiple sources rather than adopting the philosophy of one group. Rockview High School site was selected to represent the eclectic, self-determined strategy of "thinking across disciplines" reform. We chose this site because it had the following characteristics:

- the site had articulated a school-wide direction for its reform that was consistent with the direction being advocated by today's reformers
- the site had evidence of improvements for students as expressed through indicators of increased student learning and increased relevance to students' lives

- the reform was intended to be school-wide and systemic, rather than focused on a single department or on only one aspect of the school or school population (e.g., only focused on styles of teaching or only on an at risk population)

- team teaching which was designed to bring together multiple disciplines was occurring

We did not select a site that had fully accomplished its systemic curriculum reform for the simple reason that, despite extensive searching, we could not find such a site. Rather, we were repeatedly told by researchers and practitioners across the country (supported by our own experience with reform) that they knew of sites they considered to be moving along well on the journey of curriculum reform but not ones that had "arrived." They could tell us about classrooms or individual teachers or programs that were evidencing change, but not full school change.

Therefore, this study informs us about what to expect after a school has been engaged in school-wide systemic reform for a number of years, in this case, five years. The characteristics given above were taken as indicators that this school was on the road to reform. Thus we were not questioning whether or not the school was engaged in reform, but rather, we began with the assumption that the school was about as far along as any school in the country that was using this eclectic systemic reform approach.

Background Context

Beginnings of Curriculum Reform. In the winter of 1988, six months before the school opened, seven teachers were hired to work with the principal on initial planning. This group laid the groundwork for the organizational framework and curriculum of the school. A major decision made early in the planning of the school was to not have department chairs. Instead, the department chair duties were split up among members of a department. The planning group established a system where each person who takes on a particular duty which a chair normally would do is given a small amount (less than $200) of extra pay. Without department chairs, decisions about courses are made through the curriculum committee which represents all of the departments and consists of about 20 people. The committee looks at proposals for courses and evaluates whether or not the proposal meets the vision of the school. The principal is present at the committee meetings and gives input but has no final decision-making power.

The teachers' union did not support the strategy of eliminating department chairs, but Rockview was able to get a waiver in its contract. The result has been that department chair money ($15,000/year) not used for the specific duties mentioned above goes into a common pool that is used for faculty members to have time for professional development and to undertake special assignments, such as department-wide curriculum development efforts.

The initial planning group also wanted flexible scheduling with classes that met for three hour blocks every other day instead of the traditional hour block every day. Because such scheduling went against district policies that classes meet every day for one period, the group needed to apply for variances and waivers. The principal found that other high schools were implementing such schedules without having gone to policy committees for permission, but because Rockview was new, its policies were being scrutinized very carefully. The variances and waivers were granted, and the organizational framework for the school was laid.

In addition to being shrewd and politically savvy, the principal was high energy, bright, and committed to teachers being involved in making decisions. During her four year tenure as principal she guided the creation of an organizational culture of shared decision making that is being carried on by the current principal (formerly the assistant principal). The administrators' dominant orientation was that administration is a shared responsibility. Many decisions that might typically be made by the principal, assistant principal, or department chair are distributed. There is a common understanding that each of the 89 staff members (9% of whom are of color) is to share in the administrative responsibility of the school through serving on one or more of four standing committees—the Staff Governance committee, the Budget committee, the Curriculum committee, or the Professional Growth committee. These committees have a combination of governance and administrative responsibilities in that they deal with broad policy as well as the ongoing administration of that policy.

Teachers feel trusted by the administration to do what they believe is best for students. Even the evaluation process that teachers go through for their first three years in the school is viewed as supportive rather than threatening. Two main reasons for this tone of support appears to be the philosophy of the administration and the vision that bonds the faculty.

Belief Statements

The initial planning group, which included teachers and the principal, designed a broad set of belief statements (see Appendix A) which express the philosophy of systemic reform. The belief statements address learning, the nature of learners (including staff, students, and parents), curriculum, instruction, organization/ function/ operation of the high school, and evaluation process. This set of belief statements, with minor modification, has continued to guide the school through major changes (e.g. the near doubling of the student body in 1988 with a commensurate increase in teachers, the hiring of a new principal in 1992 and 1995, the hiring of a new superintendent in 1994 and the bringing in of 513 9th graders in fall 1994.)

The belief statements address the importance of learning on the part of both students and staff as well as parents. In fact, at the time of this study, the school did not have a specific set of learning outcomes for students beyond the general ones given in the vision statement. However, the district is in the process of developing such outcomes. The development of outcomes was initiated by the superintendent and spurred on by a recent state requirement in this regard.

The belief statements, driven by a changing social contexts are the guiding and navigating force in all of the schools' restructuring efforts. "Restructuring Efforts at [Rockview] High School," a 91-92 public statement of the reform underway, begins by saying:

> [Rockview] High School is committed to restructuring because the traditional model of education cannot meet the needs of students entering the twenty-first century.
>
> Restructuring calls for massive change in the culture and organization of today's schools. We must undertake that challenge if we are serious about enabling every student to reach full individual potential and be prepared to participate in the interdependent, pluralistic world in which she/he lives.
>
> Futures literature and the research on learning and quality education identified the following interrelated strategic components as those essential to systemic change of the structure of schooling: school-centered decision making and accountability; personal sense of belonging; flexible use of time and space; integrated Core curriculum; and changed roles with student as worker and teacher as facilitator.

The document goes on to outline Rockview's approach toward implementation of restructuring efforts organized around five strategic components, all of which are seen within the school as elements of ongoing, long term change—not as a single "program" put in place. The five components of the strategy are:

- School-centered decision-making and accountability
- Personal sense of belonging
- Flexible use of time and space
- Changed roles with student as worker and teacher as facilitator
- Integrated Core curriculum

Given the focus of this curriculum reform study (thinking across disciplines), it was the tenth grade American Studies Integrated Core that was investigated. The Core was the most comprehensive aspect of this type of reform in the school. (It served as the model for the teaching of the ninth grade core curriculum when ninth graders began attending the school in 1994). The other four components of school change serve as the context in which this curriculum reform is taking place, but will not be discussed in further depth.

The report that follows focuses on the Integrated Core Curriculum and its approach to teaching students to think well across curricular areas. The next two sections provide a detailed picture of the classroom situation for one core team while using one six week unit. This situation serves as the basis for the analyses and interpretations provided in subsequent sections.

II. THE REFORM CURRICULUM IN PRACTICE

The American Studies Integrated Core

The American Studies Core is an integration of Science, US history, English, and Fine Arts, and consists of a three hour block of courses required of all sophomores. The school's document explaining the Core says that Core "provides students with opportunities to make connections and understand the relationships between historical events, technological and scientific developments, artistic creations, and literary works.

The Core promotes the development of critical thinking skills necessary for problem solving and becoming responsible citizens. The diverse nature of activities in the Core meets the varied needs of students and stretches the mechanisms by which they learn. It provides a different setting for unique learnings not possible in regular classrooms."

The Core demonstrates a type of "thinking across disciplines" reform that is a strategy presently being used in a number of schools. The emphasis in "thinking across the curriculum" reform efforts is getting students to make and understand connections between discreet subject areas. Although the Core was generated by the principal and teachers as they worked together to figure out how to improve learning for students, the design resembles aspects of the philosophy of Re:Learning, a national reform effort. At the time of the study, the school was exploring the possibility of joining Re:Learning. They did so a year after this study was conducted. (See Appendix B for the principles that constitute the Re:Learning philosophy.)

During the time of this study (1992-93 school year), there were seven teams of three teachers, each team teaching groups of seventy-five to eighty students per team. All of the teaching teams consisted of a Science, History and English teacher. The school's Art teachers were available to the Core team upon request. From among the seven teams, one three-teacher team and their students were selected for this study.

Note that we wanted to find out what the reality of life in the classroom of such a school is with a team of teachers that could be considered "on the cutting edge of the middle of the road." That is, they are on the leading edge of the majority of teachers in the school but were not necessarily the team that most people agreed was the most innovative. The rationale for this choice is based in the research on the diffusion of innovations (Rogers, 1994). The diffusion research suggests that the opinion leaders within a group do not tend to be the people who are the farthest ahead in adopting an innovation but are slightly behind the most eager adopters. The team that was selected was therefore among the leaders but not necessarily the farthest along in their curriculum reform. See Appendix C for further information on selection of teachers and data collected.

In the Visitors Packet, Rockview cites an overall trend toward Core teaching as one of the reasons for the sophomore Core: "Most major [state] universities have redesigned their programs to incorporate a 'core' program into their required curriculum. At [a neighboring university], humanities majors must take a 'Science Core' while engineering students are placed in a 'Humanities Core.' We have good evidence to support that learning in an integrated setting promotes long-term learning and adds meaning to previously unrelated pieces of content."

Themes and Learnings within the Core

At the time of the study, the Core was organized around five units, each with a different theme and lasting six to eight weeks. The themes were: change, patterns, perspectives, problem solving, and diversity.

There was no particular sequence in which the Core units were used. The seven teams work out among themselves in an informal way the use of the various units to ensure the availability of materials. Each unit specifies "essential learnings" for students. Since the Perspectives Unit was the focus of this research study, we will use it to illustrate the framework provided to the Core teams. The frameworks were refined based on the ongoing work of the teams from year to year. The Perspectives Unit has the following essential learnings:

- How the American perspective changed as a result of the Civil War.
- Parallels that exist between the Civil War Era and contemporary times.

In addition, teachers select activities from a list of composition, thinking skills, and community awareness options. (Further description of topics covered in each subject area and lists of the Composition, Thinking Skills, and Community Awareness options can be found in Appendix D.) Each unit also contains a list of "Significant Learnings" for each subject area. The Significant Learnings for the Perspectives Units are given in Figure 1 below as presented in the Core description.

The materials used in each subject to target the essential and significant learnings are not set in stone. Rather, the curriculum is an evolving set of materials that have been developed by the Core teachers and the teams have the freedom to use it as they choose.

Within the teachers' work area are several file cabinets that contain readings, handouts for students, and possible student assignments that teachers have accumulated over the years of the Core. There is also a storage room in the teachers' work area that contains multiple copies of paperback books that have proven useful in the various Core units. These materials serve as resources for teachers, with each team making their own decisions about use.

Evolution of the Core

As the school's overall reform is evolving, so too is the Core. During the first years of developing and implementing the Core, teachers learned a variety of things that they would do differently. For example, the first year, each team had 115 students, which proved to be too many. They also had a three hour block with three teachers, but sometimes they had one science teacher for the first two hours and then switched to another science teacher for the third hour. This proved to be unsuccessful.

US History • What are the social, political, & economic causes of the Civil War from various perspectives? • Examine the transitional nature of the Civil War regarding strategies, technologies, & philosophy. • Use a key battle to illustrate the transitional nature of the Civil War. • Discuss the attempts to heal the nation during the Reconstruction period. • What have been the long-term impacts of the Civil War?	**STS Science** • After completing the dissection of a heart, create a diagram of the heart, label the parts, indicate the direction of blood flow, & relate structure to function. • Relate the sequence of events when a foreign substance enters the human body. Analyze a current issue related to organ tissue transplant surgery with regard to legal aspects, financial & ethical considerations, donor shortages, and donor selection. • Cite connections between the healing process of the body and Reconstruction. • Create a timeline illustrating major events in medical technology. • AIDS curriculum
Language Arts • How does Realism differ from Romanticism? • Who are the Transcendentalists and what are the characteristics of their literature? • What events of the late 1800's lead to a change from Realism to Romanticism? • Using examples from class, defend the characterization of a piece of literature as an example of Realism.	**Fine Arts** • Demonstrate understanding of the photographic process used in the 1800's and recognize their historical impact. • Use your drawing skills (grid) to complete a medical illustration of one of the heart chambers.

Figure 1. Significant Learnings for the Perspectives Unit

The periodic rotation of teachers on a team surfaced as a good idea. In the second year of the Core, rotation of teachers happened by default: teams from the first year broke up because the size of the school doubled and new teachers were hired and needed to be integrated into the Core. As is often the case, the school was, and to some degree still is, struggling with communications issues among the faculty and particularly new teachers. How do the new teachers come to understand and be a part of the culture of the school? How do they get communications patterns working, especially without department chairs, a vehicle that new teachers depended on in their previous schools?

Many of the new teachers in the second year of the school were all from one other high school, and they were interested in making Rockview like their previous school. In order to mediate the conflicts that were arising, Rockview hired a university professor, who had good facilitation skills and understood high schools, to come in and do an external evaluation. Through his evaluation, the staff was able to acknowledge where the weaknesses were, and many of the critics were assuaged.

The curriculum has also undergone changes. In the first year of the Core, parents complained, saying that the curriculum was too watered down. In the second year of the Core, students gave input on things that could be changed, such as not having assignments for the different subjects all due at the same time. Teachers have made adjustments based on these kinds of input.

All of the changes in the Core have been enriched by cooperation among the teachers. To facilitate the cooperation, teachers realized that common planning time for teams is essential, and that all avenues of communication need to be kept open. The teachers view themselves and each other as being very competent. The fact that they differ philosophically is viewed as a strength. Following the same rules as they use in seminars with students—"challenge ideas and debate but don't challenge people"—they endeavor to work things out.The teachers found that everyone must recognize that the Core will take time to become fully functioning as they desire and failure will occur, but they just need to keep at it, even though they will have to "work their tails off." The teachers believe that the continual evolution of the Core will result in a better, more effective program.

Context for the Perspectives Unit

At the time the decision was made by the researchers to focus intensively on a single Core teaching team, the team being studied was concluding their second six week thematic unit Diversity. The team had chosen to use a culminating project for the Diversity Unit--a debate on immigration. The teachers largely considered the debate to be unsuccessful. Therefore, they decided to select the Perspectives Unit because they saw it as one for which they felt they could design a particularly effective culminating unit activity. To better understand the background for the design of their culminating activity for the Perspectives Unit, a brief description of their experience with the debate that concluded the Diversity unit is provided.

A previous culminating activity. The debate at the close of the Diversity Unit was structured so that there were two teams, one opposed to immigration and the other favoring immigration. The teams were composed of 6 or 7 students. The team members were each given distinct roles to play, such as that of an immigrant or an American citizen. Each team was given 10 minutes for an opening statement which was followed by 5 minute rebuttal times for each team. The experiences of one debate illustrates the situation.

The team opposed to immigration opened first. The speaker related a stream of disconnected points with little supporting evidence. Within the first two minutes of the opening statement, five members offered points opposed to immigration, although the first speaker talked the most. Five minutes into the opening statements, the group became silent. They had run out of comments and were unprepared with anything further that would support what had been shared.

For the next four minutes nothing was said. Three students whispered among themselves and looked through their notes as if trying to come up with something to say. The team in favor of immigration was better prepared in that they filled their ten minutes with various ideas and opinions, but, again, few were supported with evidence. Through the entire debate, only four students cited any references. One was about teaching individuals to "respect other cultures." Another student spoke about how people come here for freedom and a better way of life. She read excerpts from several articles but failed to connect them to what she was saying, making her examples unclear. Another student referred to B. McClosky when discussing "carrying capacity" in the rebuttal. "B. McClosky said ethnic Americans shoulder all the burdens of being poor." And lastly, another student replied to a point with "You said they work for minimum wage, but on this sheet, this figure—I don't know if they're correct or not—more than 53% made more than $5.00 an hour." The teachers were frustrated that students "played with opinions" and "they had facts [from the course content] but didn't use them." For example, they had the fact that a very low percentage of immigrants apply for welfare.

A reference to "in-breeding" was disturbing to the teacher. A teacher said the comments came from the students' study of genetics, in which they talked about interracial children and "losing diversity." The teacher found the references to this as an attempt to try to " use contention ... in a way to form an argument, but [it] was unsophisticated."

When the debate went poorly, even in a rematch, the teachers decided to provide more structure for their next unit's culminating activity. This decision was pivotal in their choice of the Perspectives Unit as their third unit. The teachers felt that they could structure a culminating activity for the Perspectives Unit that would incorporate thinking skills, the integration of multiple perspectives, and student knowledge of most of the subject matter presented in a unit in a way in which students would succeed. They decided to use an activity called "Meeting of the Minds" for the culminating Perspectives Unit activity.

Overall, through the Perspectives Unit, the teachers were interested in addressing three problems they felt were present in the debates:

- Lack of supporting evidence used by students
- Lack of student preparation
- Lack of integration of subject areas in a sophisticated way

The Research Focus: Perspectives Unit within One Core Group

The previous section presented the essential learnings and the general design of the Perspectives Unit. Within this general structure, the Core team designed a general organizational pattern for the unit, an introductory lesson, classes for each of the subject areas of English, Science and History, special assignments in preparation for the culminating activity, and the culminating activity itself. Each of these is described below.

Organization of the Core. At the beginning of the Perspectives Unit, which coincided with the beginning of the second semester, students were reassigned among the three Core teachers as attendance groups, which serve to organize students in identifiable groups for record keeping purposes. The purpose of the reassignment was three-fold: to reallocate the number of students assigned to a single teacher after the attrition of the first semester, to redistribute groups of students who interfered with each other's learning, and to assist students in developing relationships with a wider sphere of classmates. The assignment of students to teachers was done in a discussion among the teachers of student needs and a desire to balance numbers of students evenly.

Students normally rotated among the three teachers during the three hour block, frequently at 55 minute intervals with 5 minutes of passing in-between. The teachers were situated along a single corridor in adjacent rooms with either a moveable wall divider or two 8' x 8' half-glass walled meeting rooms between. The rotation sequence depended upon the attendance group to which the student was assigned. When the students were working in thirds, they spent the first hour of the rotation with their attendance teacher, and then students (not teachers) rotated to the room to the left each of the next two hours.

In the introduction to the unit and periodically throughout the unit, the full group met together with some or all three teachers in the room.

Introduction to the unit. For the introduction to the Perspectives Unit, thirty students—those identified as being some who were comfortable getting up in front of the class—were given slips of paper that had a quotation from some person involved in the Civil War. These students came to the front of the room, gave the name or title of the person who made the statement, and read the statement. The other students' task was to write down the name/role of at least ten of the presenters, and identify in the right hand column of their paper the character's perspective on the Civil War.

As the students read their statements, one of the researchers did the task that was asked of the students. It was a fairly difficult task since the students read quickly and softly. Only one student articulated well, speaking slowly and with feeling and passion. Thus is was difficult for students to grasp the content.

Subject Area Activities

Classroom activities were most often organized by three subject areas and were led by the teacher of that subject area. In a general sense the work within each classroom related to the culminating activity but in another sense it was a separate set of activities determined and led by the particular teacher.

Activities were designed to develop student understanding and knowledge in one or more areas—the particular subject area, the unit theme of perspectives, and/or the culminating activity. The majority of the activities were dedicated solely to the particular subject area. By comparison, a small percentage of the activities were devoted to the development of the culminating activity or the perspectives theme. Most of these activities occurred in a whole group setting or with students divided into five groups, utilizing the three Core teachers and two student teachers. Very few activities were assigned to develop only the concept of perspectives. One example of such an activity was having students write about President Clinton's inauguration speech from an assigned perspective—single mother, elderly retired person, teenager, or baby boomer.

The major activities within the three content areas are described next.

English instruction. Over the six week duration of the Perspectives Unit, the equivalent of fourteen class periods were devoted to the study of American Literature. One and a half of these periods were associated with evaluation of student learning (e.g., reporting and discussion of grades). Two unobserved class periods of American Literature study were not designated on the student calendar as to the activities involved.

One major set of activities involved literary and movie excerpts of Alex Haley's *Roots*, the development of the slave perspective of the historic period, an understanding of slave literature in memoirs and code songs, and the use of the code song and spiritual styles as a form of literature. Groups of students wrote and performed code songs and spirituals using the traditional style elements.

The other major set of activities involved Literature of the War using a fairly traditional approach to the study of Whitman, Crane, Bierce and Twain (students learned biographical information and read from selected works) and the evolution of the Romanticist, Realist, and Regional literary movements (students analyzed works for literary style and elements of movement identification). The study of two authors' works, an excerpt from Twain's *Huckleberry Finn* and Bierce's poem *An Occurrence at the Owl Creek Bridge,* were also used to demonstrate two techniques of analysis—the mandala and the novel map. (See below.) This study of American Literature culminated with a quiz on the studied authors, their literature, and the literature movements their writing represented.

Additionally, students did two assignments:

Civil War novel project. The stated purpose of the Novel Project was "to show that you have read a Civil War novel and considered what the novel has to show about the era." The students could choose from among three different ways to demonstrate their learning from the novel:

- A quilt, where students were to design a collage which illustrates the themes of the novel and other ideas explored in the book. The students were to include a written page that included the title, author, and a paragraph of six to ten sentences that explained the quilt.
- A novel map, where students would choose a symbol that represented the major theme of the book and on that symbol outline the major plot events. Students were to choose colors that represented the mood of the novel. On the front, they were to include the title and author of the book and their name. On the back, they were to write a short paragraph that explained their map.
- A mandala, where students would first complete a worksheet that had them consider the protagonist of their novel in terms of what animal, plant, color, number, shape, gem or mineral, and earth element they would be. Then, using a circle or other geometrical shape, they were to illustrate the nouns and adjectives they had listed on their worksheet. They would make a "sun" side and a "shadow" side, with the sun side representing the positive aspects of the protagonist and the shadow side representing their darker side.

Novel spirals, reflection entries, and book talks. The purpose of the Novel Spirals (which refers to spiral notebooks) and Reflection Entries was for the students to show that they had read their books. In their spiral notebooks, students were to write a weekly letter and keep a calendar that indicated the amount of time the students read that week. They were required to read two and a half hours per week. Students received five points for reading and five points for writing a full page letter to their spiral partner telling about the novel they were reading. Spirals were due each week on Wednesday. Students were to pay attention to and address three elements of fiction as they read their novels: characters, conflict, and setting. Finally, students were to give a talk on a book that they had read during the year in which they would speak from the protagonist's point of view in order to "encourage [their] classmates to read a novel [they] enjoyed.

English teacher's teaching mode and status of assignments. Ms. Bergman's main mode of teaching was to give the students specific assignments, set them free to do the work—most often independently—and then, when she had deemed it time in the period to do the next task, she would regain their attention, explain or model the next task, and set them free again. The students generally stayed engaged in their classwork. However, the issues that were present in the Immigration Debate also came to play in the assignments given here. First, students continued to show "lack of supporting evidence" in that they had difficulties or were resistant to forming their own opinions based on the materials at hand and instead tended to "regurgitate" what had been said in class. Second, there was "lack of student preparation" in that many students did not complete their assignments. For their English work, students' grades ranged from 0 out of 80 to 74 out of 80. There were many zeroes and missing assignments. Finally, in the classes we saw, there was little mention by Ms. Bergman or by the students of what the students were learning in History or Science—i.e., there was little connection to the rest of the Core.

Science instruction. The study of science emphasized the connection of science and technology to society. The unit was designed to develop an understanding of the evolution of medical treatment and surgery from the time of the Civil War through the present. Three major themes were identifiable studies of 19th century science, heart anatomy, and present day immunology and organ transplants.

The introductory historic theme began with a study of medical treatment of soldiers during the war with Andersonville as a focal point. This was followed up with the movie, *Brutal Craft,* a more generalized view of the evolution of surgery. Then students read a packet of information and were to highlight or underline the important data from this material. Next they were to identify on a timeline from 1801 to 1900 all the significant scientific and technological discoveries that had been made in different science disciplines such as medicine, biology, chemistry, geology, and physical science. One timeline was turned in per group. Additionally, on the back of the timeline, the students were to respond to four or five questions regarding scientific and technological discoveries during the nineteenth century. They compared European and American successes in the sciences and highlighted the role of the Civil War in America's contributions to science.

In comparison to other assignments in other classes, relatively few students received zeroes on this project. This may be because students worked on the assignment in groups.

Next, students did a study where they developed a familiarity with heart anatomy and function, dissection techniques, and through a computer simulation, organ surgery. Following a quiz on the heart, a discussion of blood components led to the study of immunology, a presentation on AIDS, and a lab on blood typing and compatibility.

Write-ups of the computer surgery simulation and blood lab provided an opportunity to develop traditional lab skills and reporting techniques. The AIDS presentation (a district requirement) was provided by an outside medical source and was not well sequenced with student learning in other areas of the unit.

Readings, class discussion, and a structured debate about organ transplants provided the background for students to develop Organ Transplant Guidelines. These Organ Transplant Guidelines represented the culmination of the surgery science segment of the Perspectives Unit. The activity was designed to integrate student learning about the development of surgical techniques, immunology, and ethics. It required students to wrestle with the dilemmas of who, when, and how organ transplant should take place.

The Organ Transplant Guide activity was unrelated to the Meeting of the Minds. The Meeting of the Minds was set in the late 1860s and organ transplant was not a reality until the 1960s. Little connection was drawn between the two eras.

Science teacher's teaching mode and status of assignments. Ms. Peters tended to organize her class around short lectures, videos, and very structured group activities. Fewer students had zeroes in this subject than in the other two subjects. However, a substantial portion of the topics addressed were quite distinct from the Meeting of the Minds.

History instruction. In the History component, the Civil War and Reconstruction were approached geographically, historically, and politically. Geographically, the war was studied from the development of maps depicting key battles of the war. In addition to providing a chronology of events, these maps also served as a focal point of historical discussions of military strategy.

The political study of the war focused on the causes of the war, the roles of influential people at critical points of war, and the resulting political actions such as the Emancipation Proclamation. In particular, a comparison of Romanticism and Realism in war as brought out in a study of Sherman's philosophy and the strategy of Total War was designed to provide students with a clearer understanding of Sherman's ruthlessness and the bitterness of Southerners in the Reconstruction that followed.

Historical figures formed the focus of the study of the Civil War. From personalities such as Lincoln, Lee, Sherman, Davis, Grant and Booth, to the anonymous soldiers in Andersonville, Ft. Sumpter, Gettysburg, and the Massachusetts 54th Infantry, students experienced the events and consequences of the Civil War.

The major assessments of learning about the Civil War included the Civil War map, an essay on Total War (both due at intervals during the study), and a history quiz, at the completion of the unit.

History teacher's teaching mode and status of assignments. Mr. Earl's mode of teaching was generally to show videos and/or lead discussions in a lecture-type way. He would disseminate information and then occasionally ask questions, to which few students knew the answers. It appeared that oftentimes the students had not done their reading (lack of preparation) and could not give more than very brief answers to questions (lack of supporting evidence). At one point during a discussion/lecture, Mr. Earl called on a student who said he didn't know the answer. The next student also shrugged. Mr. Earl asked, "What if I gave a quiz right now?" Although he often said, "You should be making connections between this and your other work," it is doubtful if students actually *were* making the links across subject areas. Furthermore, Mr. Earl himself seldom, if ever, explained how his content linked to that of English and Science.

Fine arts instruction. The fourth component of their interdisciplinary team was Fine Arts. However, the art link was never substantially made. First, the art teacher was not a member only of this team—the teacher came in to do assignments for a number of Core teams. The art teacher did not regularly sit in on this Core team's planning sessions. In one of the planning sessions without the art teacher, the topic came up of what the art teacher should do: "Let's figure out what we want to do with her stuff before we just schedule her in, instead of just having her do it." Communications lines appeared to be tangled as the art teacher twice mixed up the day on which the Core requested that a particular lesson on Matthew Brady be taught.

The main involvement of Fine Arts in the Perspectives Unit was when the drama teacher came to the class to help students learn to do improvisations. Improvisations were intended to help students select and model the character they would be portraying in the Meeting of the Minds, the culminating activity for the Perspectives Unit.

Assignments Leading to the Culminating Activity

In addition to assignments specific to each subject area, a set of assignments were designed to lead up to the culminating demonstration. The description given to students included the following tasks for which they were responsible:

- **Bibliography** of library research, with a minimum of three resources cited correctly. These could include a novel the student read and any movies or videos seen in class or outside of class.

- **Research notes** of library research.

- A **"faction"**. (A "factor" is their term for a first person narrative about a historical character that is a combination of fact and fiction). The students were to choose a character from the Civil War period, do research on the character, and write a story about the character based on the research. The characters in Alex Haily's *Roots* were given as an example, as Kunte Kinte was a fictional character but Haily used facts and his imagination to tell the story. A draft and final copy was required. The historical character could be a scientist/technologist, writer, slave, abolitionist, union politician, union military officer, union soldier, union civilian, confederate politician, confederate military officer, confederate soldier, confederate civilian, or reconstructionist.

- **A Journal**, a minimum of four one page entries on their progress on their factions. Students were to relate their successes, failures, frustrations, suggestions, and general reflections. The entries were due every Friday.

Demonstrations of Knowledge

Factions. Some of the students' factions effectively integrated the three subject areas very well, such as one which drew on the strong emotions surrounding the war, the loss of life through battles, and the breaking apart of families. This faction also depicted the lack of medical knowledge of the time as a soldier dies in a field hospital. Another faction drew on the historical setting and events, the technology of photography, and the philosophy of the time. However, others focused more on the time in history, such as one depicting the death of the mother of a slave child. In this faction, the utilization of science was slim—only in that the woman was dying and there was no medical help for her. We were not told of what the slave woman was dying.

Transcripts from the Meetings of the Minds practice session indicated the range of depth and detail students had in their factions. Here are some fairly typical character descriptions drawn from the factions. One student did her faction on Sojourner Truth. She did not present her character in the first person as specified in the assignment.

> My character is going on a trip and she lived a block away and she was born in slavery and she became an Abolitionist like after the war. And she was married, but then like, he ran off and all kinds of stuff. I don't know that much about her, except like when they gave her a birth date, the day she was born ... they don't know what day she was born on, but they just said like 1880 something or 1786—I think it was that. She was born like that year, so they just said that year she was born, and the slavery law came out, to let slaves that were born like before 18 something, they go free. They did not really know about her. When her birth day was.

Another student said:

> I was a soldier in the Confederacy. I'm thinking about being a soldier that fought under the command of General Lee. I'm going to write about battles in which I got shot or something about conditions on battlefields and ... I don't have a lot yet.

Despite considerable library research time this student had little information.

Another student did the rehearsal, in the first person perspective and with specific facts:

> My name is Dorothea Dix. I was Irish and I was born in March, 1802, and I fought for the reform of care for the people that were mentally ill and I did that until I was 60 years old. And on January 10, 1861, I applied to be the Union Superintendent of Army Nurses and I accepted the position and I did that until the year 1866. And after that I continued fighting for the mentally ill and I died in July of 18—whatever. I don't remember.

Overall, the factions remained fairly superficial and did not bring together the disciplines very effectively.

Journaling. Journaling seemed to be a useful tool for some students. Students used the journaling to express their process of problem solving and character construction. Many students talked about books and materials they had located and where they had located them—in the public library, other libraries, from teachers. They discussed where they were on their projects and their plans for further progress. One student began by using his journal like a faction, speaking as a Union soldier in the first person from a farm in Idaho who had left "to find my life in Pennsylvania" where "the next thing I knew the war was breaking out." The teacher's comments were that "Idaho was not even a state at the time of the Civil War" and that the student should "reread [his] instruction sheet."

Another student pursued a conversation with her teacher through the journaling, seeking clarification about her character's role in the Civil War, the faction, and specific historical facts. She asked, "What side were the reconstructionists on?" The teacher wrote that she should consult her history teacher. This example from a typical student indicated a lack of interdisciplinary understanding on the part of the student and a lack of interdisciplinary instruction on the part of the teacher.

Meeting of the Minds: The Culminating Activity

The culminating activity for the Perspectives Unit was called "The Meeting of the Minds." The activity was two-fold: first, the students were to take on the identity of a fictional or factual character from the Civil War period (based on the faction they had written), explain their characters' background, discuss Civil War issues from the perspective of their characters, and express how the Civil War influenced their lives. Second, the students were to ask and answer questions of one another. They were to think of answers from the perspective of their characters and discuss among themselves their characters' stand on the Civil War.

For the actual Meeting of the Minds, students met in their already established groups of 15 students for about two hours. About one-third of the students were in costume. During the first hour, the students went around the circle and introduced themselves and told something about their lives in relation to the Civil War. During the second hour, there was a discussion between the students where they asked questions of each other. The questions included points about their biographies and general questions of interest about the thoughts, feelings, opinions, and concerns of the day. Each group had a student leader in charge of keeping the discussion going with questions that were drawn up ahead of time by the students. The students had a practice session for the Meeting of the Minds a few days before the "official" session.

There was a smooth conversation throughout the seminar with no real silent moments. The students talked about their various perspectives around the issues of slavery, the causes of the war, the loss of lives and limbs in battle, the difficulty of decisions by great political, military, and civilian leaders. There were some students who spoke little, if at all, during the second period and generally the discussion remained fairly superficial and did not reflect high level critical thinking. On the other hand, the nature of the discussion was very much in keeping with what was emphasized in the grading criteria provided. The criteria did not specifically include higher level thinking skills. Instead it was designed to move the students a step forward from what had happened with the debate. The teachers were pleased with the Meeting of the Minds in comparison to the debates of the Diversity unit. They saw definite progress from the earlier unit.

The increased clarity of the activity, the engagement of the students through playing the role of a Civil War character, the practice session, the specific grading criteria, and the greater coaching of students during the event all seemed to contribute to the activity being more successful than the debate.

Other General Classroom Patterns

As we observed classes, interacted with students and teachers, and reviewed the work of students, a number of classroom patterns and features emerged that seemed particularly relevant to the focus of the study:

1. Large numbers of students received Ds and Fs each quarter. We collected quarter grades for the first three quarters of the year. The fewest percent (19%) of the students to receive Ds and Fs was in science the first quarter and the greatest percent (50%) was in English the third quarter.

2. Many of the low grades were due to students not completing assignments.

3. Students did not appear enthusiastic about most assignments.

4. Teachers expressed much more enthusiasm for the concept of the Core than the students did.

5. Students seemed primarily focused on grades and tasks rather than on particular skills and knowledge they were to acquire.

6. Students frequently appeared uninvolved/uninterested in the activities of the class.

7. Special education students frequently expressed appreciation for the way the Core was taught and for the attention of the teachers although they did not necessarily receive high grades.

8. Considerable confusion and/or dislike of the use of a rubric (general criteria for grading) was expressed by students. The nature and role of the rubric is discussed in more detail in the next section.

III. THE CONTEXT OF CHANGE

Making Sense of the Classroom Data

Overall, the analysis of the data indicates that the approach being used by this Core team is a major advance over the initial approaches used in the school. However, both the researchers and the teachers concur that they have not yet arrived at the type of teaching and learning situation that they hope to achieve. When considering the analysis below, it is important to note that curriculum reform of this magnitude within an existing school is a complex mix of teachers learning new ways of teaching and students learning new content, skills, and ways of learning.

Our analysis first focuses on the most striking dilemma: why is it that the teachers are so enthusiastic about the Core, and yet the students do not seem either particularly excited or engaged in this high level of learning? The analysis then looks at eight key dimensions of curriculum reform in operation within the classroom.

Comparisons of Teacher and Student Learning Conditions

As we began our analysis across data sets (assignments, classroom observations, teacher planning sessions, teacher interviews, student interviews, and grading practices), we were particularly struck by the markedly different views of teachers versus students about the Core. Teachers were enthusiastic about the Core while few students seemed to value it. The students did not seem motivated by learning for learning's sake, nor did they seem especially intrigued by the content of the course.

To provide some possible explanation for the discrepancy in views, we decided to contrast the conditions surrounding teachers' *own* learning with the conditions they established for student learning. Since teachers had commented at times about how much they were learning, we thought that perhaps their enthusiasm and motivation to continue the Core approach, even when students did not evidence higher learning than in the past, was because they were motivated by the excitement of their own learning. They also seemed to have a vision of what they wanted the classroom to be, but that vision did not seem evident to the students.

To understand this phenomenon better, we selected three areas that are identified in existing research on learning as important and are also areas that the Core is seeking to embed in its operation: (a) cooperative or collaborative learning, (b) integration of content areas, and (c) responsibility for one's own learning. Although not identified by the Core as a characteristic they were embedding in their operation, we also looked at the nature of the goals, outcomes, or vision that each group held for their learning. As we looked at the differences in the teachers' learning conditions and the students' learning conditions, interesting patterns emerged that may partially explain the differing views of teachers and students about the Core.

Cooperative/Collaborative Learning

Research emphasizes the value and importance of learning with others rather than only by one's self (Jaques, 1991). It emphasizes the importance of drawing in knowledge from outside the group, processing it within the group and then using it outside the group. There is also an emphasis on developing and using creative planning, conducting research, taking risks, using thoughtful evaluation strategies, and practicing intellectual sharing with language as the vehicle and validation of both the individual's and the group's ideas (Hamm & Adams, 1992).

Teachers. We looked at how the three teachers constituted a learning group as they worked together as a teaching team. Applying these criteria to the teachers' situations and then to the students' revealed interesting differences. We looked at how the three teachers constituted a learning group as they worked together as a teaching team. They had created among themselves strong and positive communication patterns. They indeed drew in knowledge from outside the group both in terms of interesting materials that could be used in the class, research ideas about instructional techniques and knowledge about their own group of students and the context of their school. They had creative planning sessions where they generated new ideas of how to teach. They created a trusting atmosphere in which they could take risks to try new instructional methods (e.g., the Meeting of the Minds) without worrying about external judgments. They were not concerned about the principal or some other person evaluating them on the quality of their work. They could undertake their tasks, learn from the experiences, and apply their learning to improvement of the activity within their small group.

Students. The environment for group learning among students was different in a number of ways from that of the teachers. The dynamic within the student learning groups were very different from those among the three teachers. The students typically did not seem enthusiastic about working together. Although they usually seemed fairly clear on what they were to do, they were often off task and appeared uninterested in the topic.

The environment for group learning among students was different in a number of ways from that of the teachers. The students tended to work in different groups across and within the three classes depending on the activities rather than having a group with whom they worked on a regular basis as the teachers did. Students did not receive instruction or extensive practice in how to work in groups and often did not work together effectively. One teacher said that for this reason she varied how she graded students.

Sometimes she graded the group work and gave everyone in the group the same grade. Other times she gave individual grades to the group members. She said that it varied "mostly to address the complaints from those kids who say they do all the work and get the same grade." An interesting point here is that instead of supporting a change in the way the group functions, i.e., helping the group to see how they can work cooperatively, the teacher changed the grading system to support the mode of the group.

Students varied greatly in the extent to which they brought in knowledge from outside the group and the extent to which they took responsibility for taking what they did in their group and applying it outside the group, e.g., in developing their character for the Meeting of the Minds. Times when all students in the group actively participated in developing and using creative planning strategies were rare. The technique of letting the "most academic" or "grade conscious" student do the work was most common.

The students' strategy for completing work was primarily the use of immediately available sources such as textbooks, notes, and individual recollection. Typically risk taking was avoided to minimize grade penalties. Comments would be made by teachers throughout the courses about how students needed to function differently (e.g., take more responsibility for their own learning) but because the comments were isolated and were interjected into a strong and opposing culture, they seemed to make only a minor dent in student actions.

In contrast, the teacher team had been working together for three years and had far greater communication skills than the students. The students did not have the wealth of general communication skills and did not have familiarity with the others in the group to nearly the extent of the teachers. Time was not spent at the beginning of the year helping kids to get to know one another and working out ways that groups would be formed throughout the year so students had a general sense of what to expect. Students were not specifically taught how to engage in creative planning, thoughtful evaluation, risk taking, and research strategies that they would need to build and demonstrate during the year.

Students tended to focus primarily on completing an assignment for a grade rather than developing their ideas or learning particular skills. Students tended to focus primarily on completing an assignment for a grade rather than developing their ideas or learning particular skills. Students' experiences with evaluation strategies tended to be primarily that of having teachers judge their performance for the purpose of grading. They were not involved in much peer review of practices of performances.

Integration of Curricula

For purposes of this discussion we will use the description of Jacobs (1989) for an interdisciplinary instructional approach--a knowledge view and curriculum approach that consciously applies methodology and language from more than one discipline to examine a central theme, issue, problem, topic, or experience. According to Jacob, interdisciplinary curriculum and teaching require:

- a scope and sequence
- a cognitive taxonomy to encourage thinking skills
- behavioral indicators of attitudinal change
- a solid evaluation scheme
- the use of both discipline-field-based and interdisciplinary experiences.

In looking at this issue, we considered three aspects: How did the teachers develop their own interdisciplinary thinking, how did they present the interdisciplinary nature of the curriculum to students, and how did students perceive the notion of interdisciplinary content?

Teachers. The teachers had spent considerable time, both within their individual team and in previous years, working on bringing knowledge together across subject areas. Doing so was one of their main goals for the Perspectives Unit. The Meeting of the Minds assignment sheet read: "This is an all Core project and therefore you will be expected to integrate social studies, English and science." However, there was no clear plan or outline of how these connections would be accomplished.

There was no clear plan or outline of how these connections would be accomplished. Instead students were often reminded to make connections but seldom did we see teachers provide examples of connections or explanations to students of how to do so. An example of this is in Mr. Earl's class, where at one point he said: "If you are sitting there, letting things float by and not making connections between your Civil War character and this stuff you are missing your opportunity." However, he did not say how the students could be making the connections. There did not appear to be a recognition of the particular skills students needed to make the connection.

In a planning session, one teacher suggested "spending some time with each individual and trying to guide them in order to help students see the connections between disciplines." But another teacher responded that would take too much time.

What is more, the teachers also appeared to be uncertain about what connections students were supposed to see across the disciplines. It appeared that they typically had not made strong connections among the disciplines for themselves, so it is not surprising that they did not particularly help students do so.

In a planning session, the following conversations ensued:

> Teacher 1: *I think we would want them to be able to obviously, through this process they're going to be looking at the Civil War through one point of view, or through one perspective, and I guess, not only to identify that, but then to be able to appreciate other perspectives.*
>
> Teacher 2: *If we go back to looking at some of the things in our big rubric, is there anything in there that we could also focus on, for this particular unit?*
>
> Teacher 3: *Self-directed learning certainly doing some research understands other perspectives.*

However, in this discussion and subsequently in the planning session, there was little talk about the specifics of what each teacher would do to support these goals, how content could be integrated across subject areas, or what skills they needed to teach to get the students to the 'expert' level in the rubric.

This is not to say that the teachers are unaware of the need to work in tandem. During the same planning session, the teachers agreed that they needed "something that will tie us all together." The following conversation occurred:

> Teacher A: Is it going to become what we've done in the past, which we haven't done this year, where we give them a project at the beginning and then we just sort of forget it and just expect them to be doing it, or are we going to make sure that everything that we're doing is really shooting toward that?
>
> Teacher B: ... What kind of question is that? (good-naturedly)
>
> Teacher A: Because I can see it happening that way!! ... The real reason I'm thinking that is that I'm sitting here trying to figure out exactly what I'm going to do in terms of the literature component or giving them time to read the books or doing the writing and that sort of stuff and that if I make sure that I'm shooting towards that, then what I set up is really going to be, it's going to be real different.
>
> Teacher C: OK, and the other thing that we've talked about, the fact that is, that do we want to give them long range projects because do we lose (interrupted by Teacher A)
>
> Teacher A: Or do we want to set up steps to get there?
>
> Teacher B: You know what helps, could help, the way that the Civil War series which, I would never show the whole thing, but a few bits and pieces ...

Also, the teachers only learned enough about each other's disciplines to be able to give students some examples of relationships among the subjects and to be able to identify topics to teach in parallel. They did not get into learning the underlying disciplinary methods to be able to explain these features to students. In a private interview, Mr. Earl explained the connections that he was seeing between English and History: "One thing that I emphasize in the History part of the Perspectives Unit is the way the war changed ... So the way that at the end of the war was romantic, there were still those traditional beliefs about war and the way it should be fought and all that stuff and by the end how that had all changed. And that coincides just wonderfully with the examination in English, of the romantic literature and the realistic literature.." But do the students see the link between the shifts from romanticism to realism in both history and English?

Mr. Earl went on to say that the links with science were a lot weaker. He said that at the beginning [with the time line during the Civil War], the links were there but then the science got moved into "new medical technology transplants" so "we sort of lost that connection."

He said, "And that's, I guess, that's fairly common, that there's usually at least a strong connection between two [disciplines]. I mean if you can get all three that's great and if you can make it real strong, it's better, but a lot of times ... I get the feeling sometimes that it's kind of shaky. It's thematic, but I'm not even sure how the theme has been worked into the science part of this Perspectives Unit ... I'm not sure that even the thematic title is emphasized in science in this unit ... The science just doesn't work now."

How then, are students supposed to make the connections with science? It seems that the teachers want to be teaching interdisciplinary, but in fact are teaching their subjects not in concert with one another but in parallel with one another.

It appeared from discussions with the teachers of this Core at least, that there was a strong desire and tendency to retain their own subject area as well as bring about links. For various reasons, they were not willing to move much beyond the traditional boundaries of their discipline. In some cases, this was because they felt a strong allegiance to their discipline area and felt that it would not be professionally acceptable for them to let go of many of the topics that they felt needed to be covered in the curriculum for this grade. Thus, they did not teach one another's subject areas or build truly integrated units that brought the content together. They did not seem to have had a thorough discussion of the pros and cons of various degrees of integration of the disciplines and were operating more from the basis of personal comfort with the content rather than being driven by a set of goals about how students perceive and use knowledge and skills that help them build a depth of understanding of their world through thinking across disciplines.

Students. A good number of students recognized the value of integration of curriculum. However, the connections they made were typically weak. As evidenced in the interview below, the students basically saw the Core as three separate subjects with the culminating activity being layered on as if it were a fourth subject. They did not see a clear scope and sequence to the themes or a set of skills and knowledge they were to acquire. Nor did they sense an integrative, interdisciplinary single subject focus.

> Interviewer: How do you feel about the integration of science topics, English and social studies?
>
> Student 1: I think it's better this way because that's how it is in the world and outside the schools.
>
> Interviewer: This whole business of trying to integrate, is it useful?
>
> Student 2: I would do better if the classes were completely separate, but it works. But I don't like it. I don't really know why, I just don't. I seem to do better in my other classes than Core. ... I get better grades in my other classes.
>
> Interviewer: How do the [Core] units work?
>
> Student 3: Well, from what I get from it, every class has like, something going on in it, and then all together we have like an overall assignment, so you kinda got double payload for Core ... It doesn't make too much sense to me. You know, having three classes, three regular assignments just like any other class and then you have one overall too.

Responsibility for Learning

One of the major goals of the Core teachers is to have their students become self-directed, self-motivated learners who use higher order cognitive strategies independently and in connections with other learners. Rosenshine and Meister (1992) say that such learning develops through scaffolding where students are presented with new cognitive strategies where the difficulty is regulated through guided practice and varying contexts are used for student practice. The teachers provide the students with feedback and students are given increasingly greater responsibility and independent practice. Meanwhile, few students appeared to be self directed, self motivated, life long learners.

When looking at the development of learning patterns and responsibility for learning we found very different situations between the teachers and the students. Teachers both perceived themselves as - and exhibited behaviors of - being very self directed, self motivated, life long learners. They were very supportive of their colleagues' learning and developed a learning network among themselves.

Meanwhile, few students appeared to be self directed, self motivated, life long learners. In their planning sessions, the teachers talked often about wanting to get students to go the extra step:

> Teacher 1: My concern is, again, are they just gonna tell us ... 'well in Roots I heard about this so this is probably what it would have been like ... In the movie I heard about this ...' It's just again giving us what we've done in class and no more than that, and we're saying that's OK.
>
> Teacher 2: I'm afraid on a couple of these characters, all they're going to do is regurgitate stuff in class and think that's it, and they won't do any outside stuff.
>
> Teacher 1: [What if] we do lots of 'what-if' questions and have them really writing and thinking about it. Then they're learning more, to try and push beyond exactly what we're saying. Then maybe they will have been prodded into thinking beyond what we have here. Like, 'so how would this look if you were General Lee instead of Grant? Or what if you were a surgeon right here in the middle of Antitum?'

There is no response to this teacher's suggestion. The next teacher's comment was, "Are they going to present this in front of the whole Core? Just in front of their little group?" That question, an easier, logistical question, was pursued and discussed in depth.

> Teacher 1: I think that ... the stuff that we talk about in English should inform also in terms of what they're doing ... Not that they're repeating exactly what we talk about in there, but maybe they're looking at it a little bit differently. And maybe they're applying it to their particular role whereas I may not make that connection in the class.

Again, it's clear that the teachers want the students to take their class information farther than indicated by the teacher's presentation. But again, there's no discussion about how the students could do this, or what the teachers could do to help the students get to this point.

The same teacher who made the comment just above, aware of this, said, "The question is not whether or not they will but whether or not we set it up so that they will." And a key moment came when another teacher said, "I think I maybe overestimate them."

In an interview with one of the teachers, the interviewer asked, "How do you think that [the students] could be better engaged in this unit?" The teacher's response was vague: "I'm sure they could be better engaged, but I'm not sure that it would be a whole lot different than what we're doing." In other words, the teacher did not seem to know what to do to get the students more involved in the unit. In fact, the teachers appeared to have an attitude of helplessness and fate when it came to whether or not the students would become engaged in the activities.

> Teacher 1: I'm always the skeptic on those things. We've had so many, just out and out failures, that it looks like things are going a little better. I'm keeping my fingers crossed for the final project, but some kids are doing some good research and putting in some efforts and, based on the journals [the Reflections] it sounds like they're getting somewhere, and maybe they are and maybe they aren't.
>
> Teacher 2: I hope it turns out good.
>
> Teacher 3: ... when we're fortunate enough to hook them in ....

It also appeared that students needed a lot more guidance on how they might become self-motivated learners. An example of this occurred in Mr. Earl's class when he said, "If your character is a soldier, you could ... put down info about weapons ... Use it as a source. Make yourself more self-directed." The phrase, "Make yourself more self-directed," though perhaps unintentional, seemed indicative of what is expected.

These characteristics are in marked contrast to the characteristics that research indicates should be present. As noted earlier, self responsibility develops through scaffolding where students are presented with new cognitive strategies, the difficulty is regulated through guided practice, and varying contexts are used for student practice. The students are provided with feedback and students are given greater responsibility and independent practice.

Goals and Vision for Learning

Another pattern characterized the situation: there was little or no articulation of was to be learned by either students or teachers. Teachers seemed to have a driving general vision of a transformed classroom but they did not seem to have a clear idea of what they needed to do to achieve it. They seemed to pick up on recent ideas they had heard about and tried to apply them. They did this with enthusiasm. They appeared to be motivated by the challenge of putting together new ways of doing things. On the other hand, students seemed to have a very weak sense of what the Core's approach to learning would accomplish for them and specifically what they were to learn. It appeared that students needed a lot more guidance on what they were supposed to be learning and why.

There was strikingly little mention of the skills and knowledge that students were to acquire through Core. In fact, during the planning sessions the three most frequently mentioned skills were bibliography creation, taking research notes, and note taking during class. Note taking was particularly important to the teachers, apparently because the students were not in the habit of doing it. Oftentimes, even after the teacher had suggested that students take notes, the students wouldn't. The teachers then felt that it was important to get the students in the practice of note taking, and that note taking constituted an example of students showing 'expert' characteristics. For example, during a class period, one teacher said in the middle of the discussion/lecture, "If there are any people here who are becoming a self-directed learner, feel free to jot this stuff down." Up until that point, no one was taking notes.

In another situation (the Introduction to the Perspectives Unit), Ms. Bergman commented to several students that one of the things they were trying to have students concentrate more on was note taking. However, this was not stated up front to the whole group. Again, here was an example of the teachers having a purpose for an activity but not making it explicit to the students up front. Finally, each time note taking was recommended, there was no discussion of how the notes would be used in the future.

With note taking skills being such an emphasis, it is not hard to understand why 'higher order skills' did not receive focused attention. When asked what 'major activities or techniques or projects' were done "to promote thinking skills in the unit," the teacher was vague: "I always hesitate here, because I have a hard time sometimes thinking of those. ... I can't say we've done a whole lot of structured things. The thinking skills have hopefully shown up. ... I know they're thinking."

Although at least two major assignments that were analyzed show thinking skills, this teacher did not cite them. Generally it appeared that the teachers were not precise on what they are shooting for and what they and the students need to do to get there. Consequently, activities that do embody thinking skills are not clearly identified by teachers or students as a means of acquiring certain skills.

Summary. Overall, contrasting the learning conditions that existed for teachers and students and/or the gaps between what teachers said they wanted and their practice revealed important aspects of the program that needed strengthening. The contrasts also highlight the value of teachers reflecting on their own learning and practice as a way to help determine why student learning is not as strong as it might be.

Rockview High School and Key Curriculum Reform Dimensions

We now chart Rockview's placement in regard to eight key dimensions of curriculum reform that existing research indicates are important in developing thinking abilities among students. In doing so, let us first note that in general the school has directed its attention to the conditions that research shows are key to curriculum reform. They have:

- established the general learning they desired of students (although the skills and knowledge may not be as clearly defined as is needed)

- built connections among content areas using important themes that touch the everyday lives of students

- created a climate of teachers as ongoing learners and developers of curriculum

- moved away from single textbooks in subject areas to the use of resource materials, primary source documents

- a fairly smooth way of sharing materials across 21 Core teachers (seven teams) block scheduling in place for the Core

- developed a strong atmosphere of trust and respect among teachers and administrators throughout the school.

They appear to have gone far enough down the path of reform that they don't seem likely to turn back. The challenge, however, seems to be whether they can break through to a truly reformed teaching and learning strategy or whether they will continue on with many promising but only partially developed techniques that do produce high level thinking and learning among students.

Our purpose in this analysis is to gain a better understanding of the dynamics of change within these eight aspects of curriculum reform and to understand what aspects are likely to be most significant as they progress in their journey of reform. The eight aspects are:

- Goals
- Content
- Teacher Role
- Student Role
- Student Work
- Assessment
- Teacher Learning
- Organization

Goals. As we studied both the written materials from Rockview and the data collected via this study, we found what we think are some key features of the school goals that may explain why student learning has not been greatly enhanced by the Core. The school has a strong set of beliefs and vision for the school as it relates to general conditions for teaching and learning, but neither the school, the Core, nor the Core team being studied has articulated clearly what the students should know, be able to do, and be like. Closely and significantly related is the meaningfulness of the learning.

First in regard to clarity, the schools' belief statements address processes and conditions but not the end result of the learning experience. The Core materials get a little closer by specifying essential learnings for each thematic unit. However, most of the emphasis in the Core description is on what topics are to be covered in each subject area included in the Core.

The essential learnings are not clear on just what students are to learn. For example, for the Perspectives Unit, the essential learnings are stated as:

- How the American perspective changed as a result of the Civil War
- Parallels that exist between the Civil War Era and contemporary times

Tied to the clarity issue is the finding that there is no indication of whether such knowledge is to be derived from simply recalling what teachers say on these topics or if students are to develop these ideas for themselves.

The Core materials also indicate that certain thinking skills are to be identified by the Core teachers for emphasis. In the Perspectives Unit, the skills from which one or more is to be selected are:

- Use of primary sources in historical research
- Timeliness
- Connecting events of past to the present

Again, these are stated in a way that does not make clear what thinking skills students are actually to acquire. For example, in the Perspectives Unit, timeliness were constructed in science. But how much students developed thinking skills via this task was basically determined by how structured the teacher designed the task. The task given in science tended to be structured by the teacher with the student simply finding information in the resource materials and putting them by the relevant date. The analytic or synthesizing skills (the thinking skills) were not articulated for the students nor did the teacher seem particularly focused on them. Thus the Core teams seem to have gotten as far as focusing on certain themes and overall questions for students to address, but they have not clearly articulated the learning goals for students.

A closely related, and perhaps even more significant, issue is the meaningfulness of what students are expected to learn. The classroom situations indicated that what students are expected to learn (or at least what they think they are to learn) is not particularly meaningful and engaging to them.

These features of the goals appear to be highly significant. If students are not clear on what they are to be learning and/or if it is not important to them, the tendency is simply to focus on carrying out a task with little attention to the fundamental skills to be acquired or its importance to them.

In our discussions with teachers we found that when they talked about goals, they tended to focus on goals related to the organization of the Core such as using block schedules or integrating curriculum, not goals of what students should learn.

Of critical importance here is moving away from goals concerning the organizational features of the Core and school to learning goals for students. Hopefully, these will incorporate thinking skills and habits combined with strong content in the disciplines. It will also be important to emphasize casting the learning goals in ways that are meaningful.

Content. The school took a major step forward on the design of curriculum content when it chose early on to develop an integrated Core curriculum. They focused on the "less is more" philosophy and have built connections among content areas by the use of overarching contemporary themes. The team we studied was struggling within itself to retain a strong content base in the subject areas and also build interdisciplinary connections.

The team has a long way to go to bring together a clear focus on thinking process skills with rich content. They are currently at the point of teaching the subject areas side by side with attention to connections among the subjects content-wise. Perhaps the reason they have not been able to get students to move beyond very basic factual information to going more deeply into content areas is because they are not consciously teaching students thinking skills such as analyzing and comparing and contrasting across subject areas. Students are not being taught how to process information, integrate content, and apply knowledge in new situations.

Again, the organizational framework (block schedule, themes, intention to integrate content areas) are here and ready to be used to move to rich content. However, these conditions are insufficient. Teachers are now faced with the challenge of helping students learn and apply the thinking skills in order to move forward to the point where students are focused on a conceptual understanding of the content rather than simply learning facts.

Teacher role. The teachers within this team differ in their dominant teaching methods. The science teacher tends to use group work frequently; the history teacher tends to rely heavily on lectures and videos with questioning of students to elicit specific right answers; and the English teacher has students work on projects while she circulates responding to their questions and needs. Thus, the teachers vary in the extent to which they apply the principle of "students as worker, teacher as coach."

It does not seem that it is the teaching method per se that is the key. Even with a heavy lecture format, by changing the nature of the questions that students address from ones that are simple factual recall to ones that require analysis and synthesis, the teacher role can shift from dispenser of knowledge to coach and facilitator.

The English teacher plays the most facilitative role, moving about the room as students work on their projects. The science teacher does this to some extent but relies more heavily on providing very clear directions and expecting students to figure things out from there.

Each of the teachers seems to have moved toward more of a facilitative role from where they previously were in their teaching, but in none of the cases have they fully developed a role where they clearly model the process they go through to figure things out, process information, conduct research, and brainstorm ideas. Nor do they explicitly give students guided practices in developing thinking skills. This may account for why students are more attentive to simply completing a task rather than gaining certain thinking skills, knowledge, and habits. This situation seems closely tied to the lack of articulation of the thinking skills that they expect students to gain and the lack of clarity of the desired integration of the three content areas in the Meeting of Minds.

Student role. The belief statements of the schools emphasize that students are to take responsibility for their own learning. Teachers frequently commented to the students that they wanted them to be self-directed. However, there was little explanation of what this means or how to do it. Among the three subject areas, the students seemed to function in the most self directed way in the English class/assignments and least in the history class/assignments. The greatest amount of self direction came in the Meeting of the Minds activity. Yet, it seems that there is a long way to go before students are truly self directed.

The general theme of the student role seems to be completing the task at hand rather than acquiring certain knowledge, skills and habits. Yet, the high percentage of F's indicates that even this is not happening to a high degree. Many students were not finishing things, giving the impression that the work was not important to them, they just didn't "get it," or they didn't take the time or locate the materials to do it.

Student work. In one sense, the Core is quite advanced in the type of student work being required. Students are involved in science labs, they have projects they are working on in the English class and they have the overarching Meeting of the Minds event. Yet, in another sense these projects and activities seem shallow. Why might this be?

First of all, the student projects being carried out were not designed in a way to be personally meaningful to the students. Few, if any, of the tasks had obvious applications to the students' everyday lives or built on their personal interests. Two notable exceptions were the selection of books to be read and the character they were to play in the Meeting of the Minds, which did emphasize personal interest.

Secondly, the teachers designed all the projects of the unit and gave students little sense of how they all fit together and how they built toward the culminating activity. The teachers individually (for their classes and for the activities specifically linked to the Meeting of the Minds) had an understanding of the connections but the students never seemed to get this big picture. The approach used was quite different than if, say, the teachers had laid out a range of projects students might do to build toward the Meeting of the Minds and then had students construct their own plan for getting there.

The major next step here seems to be to design the student work so that the student instead of the teacher is doing more of the "thinking" tasks. For example, one approach would be to focus students' attention on the culminating activity at the beginning of the unit and then describe options of types of projects/activities they could do within and across the subject areas. Students would then be asked to select the activities that they think will best help them achieve high quality in the culminating activity. Students would develop their own timeliness and tasks for the set of activities and would establish an agreement with the teacher on the full set of work for a unit. Such an approach moves toward greater self responsibility for the student and helps shift the teacher role to a coaching role. It also moves many important "thinking" tasks from the teacher to the student.

A second dimension of designing student work to promote higher thinking would be to provide greater connections to student interests. This might be done by building in more real life and current connections and giving students more choice on topics.

Assessment. The most noticeable feature of the assessment of student learning was that both students and teachers emphasized assigning a grade rather than what skills and knowledge students acquired. In terms of the assessment tasks themselves, the teachers had moved away from worksheets and measurement of discreet information to more project based assessment. However, they were at a very rudimentary stage of defining what constituted quality work. They had developed (for the first time for the Core) a general rubric (i.e. a set of guidelines used to score student work). However, the rubric had weaknesses.

Let's look more closely at the general rubric and the more specific rubrics developed for specific assignments. Since the development of rubrics and redefining grading is a big aspect of much of today's curriculum reform. First the general rubric. (Figure 2 contains a copy of the rubric given to students at the beginning of the year.) The students tended to focus most heavily on the labels for the three levels of the rubric - novice, intermediate, and expert. They did not understand how they could be experts in everything. They thought that they had to be in the expert category to receive an A despite teachers saying this was not the case.

The subheadings for the three levels of the rubric were confusing. The Novice subheading was "knowledge and comprehension," the intermediate subheading "application and analysis," and the expert subheading was "synthesis and evaluation." Yet the information in the boxes of the matrix did not parallel these categories.

The rubric then had four categories of (apparently) knowledge and skills that students were to be developing over the course of the year. However, these four categories were unclear and unconnected to specific skills or knowledge. The four categories were (a) integration, (b) self-directed learning, (c) perspectives, and (d) consequences. Yet there were no further definitions of these terms so that students would know what they meant. The bullets within the matrix of the rubric were probably intended to convey these specifics but they were typically vague statements that lent little clarity.

This form of Novice/Intermediate/Expert rubric was intended to show students "that learning is a process that continues and that they can get better and better at it." The teachers wanted to identify the skills that exist at different levels, so that students could push toward the expert level. Mr. Earl said that the teachers tried to communicate to students that "we don't expect you to be there now, but we expect you to be aware of what it takes" to be there. During a class at the beginning of the Perspectives Unit, Mr. Earl told his students: "If you don't have the rubric, get a copy. Keep it handy and make references to it." Again, he didn't explain *how* to use the rubric.

	NOVICE Knowledge & Comprehension	INTERMEDIATE Application & Analysis	EXPERT Synthesis & Evaluation
Integration	• makes connections between two areas • recognizes connections when pointed out	• makes unsolicited connections • makes connections within unit	• creates connections to material outside course content • evaluates appropriateness of connections • uses past, present, and future • relates connections to society & personal lives
Self Directed Learning	• only does unassigned work for extra credit • does minimal effort • relies on others for direction	• seeks additional resources • occasionally participates in out-of-class activities • completes class assignments with core and pride	• actively seeks outside of class • develops a passion area • moves beyond class assignment
Perspectives	• adopts one perspective	• understands others perspective • identifies relationships • assesses own perspective	• analyzes implications of own perspectives • considers and analyzes other perspectives and adjusts when appropriate
Consequences	• understands/predicts consequences	• understands/predicts consequences	• evaluates political, social, economic, aesthetic consequences • takes appropriate action

Figure 2 - General Rubric for the American Studies CORE Rubric

Students do need to be able to evaluate themselves, but it seemed that the emphasis of the rubric was ill-placed. As it is, the rubric structure, "Novice/Intermediate/Expert", seems to evaluate the *student*, not the *student's work*. There were some parent/student complaints about this, where the student felt classified according to ability. "Some of them saw it as a tool that put them into groups and then they were forever labeled as a novice learner ... They see it as a totally new and unfair way of grading, ..." said one teacher. "I used to think they're all away from all that until about two weeks ago, a mom was concerned that this thing had labeled her daughter, she was grouped and she was kind of locked into this ... It was just real strange the way that they perceive it."

A specific rubric was established for the Meeting of the Minds event. Other rubrics were used for specific assignments especially by the English teacher and for activities leading to the

Meeting of the Minds. The emphasis was on using the rubric to determine grades rather than on the learning of desired skills and knowledge.

The rubric for the Meeting of the Minds is of special interest. It is shown in Figure 3.

	(# of Comments / # of Points)		
Demonstration of Content Covered	1-2/3	3/8	4+/9-10
Participation	1-2/3	3/4	4+/5
Discussion Skills	1-2/3	3/4	4+/5
Perspective of Character	More you than the character Increasing more the character		7 8-10

Figure 3 - Rubric for the Meeting of the Minds

Here, the grading rubric focused more on the number of times students spoke in the seminar rather than on the depth and insight of the students' comments. Yet the rubric does deal with the basic issues of focusing on having students provide content, participate and demonstrate discussion skills—the problems the teachers identified in the Diversity Unit debate.

Rubrics for the faction, novel project and book talks are given in Appendix E. The book talk rubric illustrated another aspect of establishing quality in the students' minds. The third level of the rubric, labeled as "Acceptable" said:

> The time is not even close to the two-three minute requirement; book talk seems unpracticed; not told from the first person point of view; the audience isn't pulled in because the presenter seems bored by the book; presenter has read the novel.

Why is it "acceptable" if the students don't meet the time length requirement, if the talk is unpracticed, not told from the correct perspective, and is generally uninteresting? It seems that the rubric guides teachers as to how to grade students' performances rather than guiding students to do their work with quality.

Overall, the rubrics appeared to have very mixed effects on students. On one hand, students realized that there were some things they were to learn and be able to do, but on the other hand, their major attention was directed to the labels for the stages of the rubric and/or the consequent grading. They repeatedly talked about how their teachers expected them to be experts in everything. To get an A they needed to be an expert. They talked much of how all students are different and they need to be judged against their own potential. The comments seemed to be a combination of genuine perceptions of inappropriate expectations along with resistance to doing more work than they thought reasonable based on past experience or experiences in other classes.

Possible Assessment Changes. The modes of assessment and particularly the use of rubrics seem to be a key leverage point for strengthening the focus on what skills and knowledge students are to acquire. Consider, for example, how the general rubric might be redesigned. It could be set up to focus on the habits that are desired of students. There might be three habits that cut across the whole Core, along with sets that are specific to a given Core unit.

Habits for students to develop that cut across all Core units.
- Integration of knowledge and skills across subject areas
- Self-directed learning
- Critical inquiry

Unit specific habits for students to develop.
- Perspectives
- Diversity
- Change
- Problem solving
- Patterns

The levels of quality within the rubric could be changed to something like "initial," "moderate" and "advanced" rather than "novice," "intermediate" and "expert." The important point is that whatever terms are used refer to the level of skills, not a descriptor of the learner. The rubric would have specific *thinking skills* defined in the cells of the matrix. A second version of the rubric could have the *knowledge/content* that should be mastered at each level of quality.

It is not just the design of the rubric, however. It is also how it is used instructionally. Rubrics may be useful, for example, to arrange things instructionally so within each unit students focus first on developing the "initial" level of each habit through fairly guided experiences, and then moving on to more self-directed learning of the habit at a higher level. Perhaps achieving the initial level would involve the student being able to articulate to a reasonable degree what this habit looks like when it is well developed, thus giving the student a clearer picture of their target. With this basic level of understanding, the instructional approach could call for students to take more and more responsibility for defining and carrying out the activities they undertake in order to demonstrate their use of the habit within the culminating activity.

The opening weeks of school might focus on the three general habits so that students would get to know the basic skills necessary to each. For example, note-taking may be a part of critical inquiry. The many available resources that define thinking skills could be reviewed to help articulate the desired skills. Students would be focused on understanding how these habits build over time.

Certain instructional approaches might build across the units in keeping with student progress. For example, instruction might move from the teacher defining the culminating activity with the rubrics/criteria specified to students doing both the identification of the culminating activity and the rubrics/criteria to use in judging its quality.

Such changes would also allow a shift in grading practices to emphasize the acquisition of habits, skills, and knowledge rather than simply completing assignments and accumulating points.

Grading. As noted above, the dominant assessment feature of the situation was the heavy emphasis on grading. Although the teachers talked about wanting to focus on skills and knowledge, their actions emphasized grading. When they developed criteria for assignments, they identified things students had to do to get a certain number of points. These points directly converted into grades. The emphasis was not on highlighting acquired skills and knowledge. In fact, the criteria used for getting certain points often was devoid of specification of skills and knowledge.

Teacher Learning. A very positive characteristic of the Core team was the way in which the teachers functioned as a "learning community" among themselves. They openly learned from one another and were eager to apply new ideas that they acquired through outside conferences and other sources. However, the knowledge of new practices that they acquired from outside sources was typically introductory and they did not have mechanisms in place to push to deeper levels of understanding before applying new techniques.

For example, there were no mechanisms in place for teachers to draft, say, a rubric with guidance from people who had experience in the development of rubrics or to have their work reviewed by outsiders with this kind of background. In other cases, some, but not all, teachers received exposure to, or more thorough training in, a technique such as cooperative learning. However, there were not well developed ways for others to learn these skills or for those who had gotten some training to develop the skills to a more proficient level.

Most of what they were trying to do, they were learning by their own trial and error, rather than also drawing more fully on the experience/expertise of others. They were excited about that learning process, but their own learning so consumed their energy that they had difficulty looking at assignments and classroom practices from the perspective of the students, e.g., how students were likely to interpret assignments and purposes.

Organization. When one looks at the belief statements of Rockview and the areas of emphasis of the Core to date, one sees that it has been the organizational features that have received the greatest attention. They have succeeded in putting in place several valuable organizational features:

- Interdisciplinary teaching around themes
- Block scheduling
- Common planning time for the teams
- Use of culminating activities
- Use of group work

Interviews with other Core teachers besides those focused on in this study indicated that the first three features were particularly attractive because teachers viewed them as making teaching easier. However, they had paid less attention to how the organizational features impacted student learning. In any event, the challenge they now face is how to best take advantage of these features to move toward greater learning for students.

For example, although Rockview has block scheduling, the classes are most often three one-period per subject classes backed up to one another with a common group of students. As they develop their interdisciplinary content and better connect the disciplines-specific content, all three teachers may well be teaching content from all three subjects in a truly integrated unit.

It is interesting to note that teacher's attention to organizational concerns before impact on student learning is what one would predict from the research on teacher's stages of concern when adopting innovations (Hall and Hord, 1984).

IV. CONCLUSIONS AND IMPLICATIONS

Lessons Being Learned at Rockview

What does this look into the classroom tell us about curriculum reform in situations where a school is seeking deep, systemic change and where they have developed their own strategy of reform (rather than following a particular process, philosophy, or set of materials developed by outsiders)?

Before answering this question, recall that this school was newly formed five years before the study. It is in a fairly traditional district and community, it drew students and teachers together who had little or no history together, and set them in the context of a new philosophy of schooling within a new building. Large numbers of people were involved - nearly 1500 students and 90 teachers not to mention administrators and community members. Anyone who has attempted to change a norm among a small group of people (as straightforward as proper table manners within the family) recognizes that considerable practice and discussion are needed for change. Multiple this amount of practice and discussion by the number of factors and people involved in curriculum reform in a situation such as Rockview and one should not be surprised that it takes a good number of years to accomplish.

The issue is not, why haven't them completed their reform, but rather what can we learn, and what are they learning, about the complex process of curriculum reform focused on thinking across disciplines.

Five lessons stand out. We state them below in terms of actions to be considered by Rockview and other schools involved in this type of reform. These lessons are not necessarily fully confirmed by this one situation. However, these are the issues that appear to us, based on our analyses and reflections on other research to be most worthy of consideration by Rockview and similar schools as well as worthy of further research.

Focus on creating a learning community. Increasing emphasis is being placed in the literature on the importance of changing the mindset about education reform to one where the education system's goal is to create a learning organization (Fullan, 1993) or a learning community (McLaughlin, 1993). The complexity of learning to think well for both students and teachers reinforces the need for creating a learning community. However, previous research emphasizes a learning community among teachers, whereas this study emphasizes the need for a learning community that encompasses **both** students and teachers. Their roles and tasks are so intertwined that a learning community that excludes students appears far less powerful than one that creates a dynamic and explicit interchange among students and teachers.

Teachers, however, are the ones who largely determine the nature and extent of the learning community. It appears that their attention needs to be directed toward ways they can create a shared learning community that encompasses but students and teachers. This may involve creating situations where intensive learning is going on just among teachers and just among students but then also incorporates a similar dynamic that involves both groups.

Watch for the parallels between student and teacher learning. The analysis in section IV highlights the nature of the parallels between student and teacher learning. Given all of the things that are going on in a classroom, finding parallels and learning from one situation and transferring that learning to another both saves time and engages teachers in the kind of thinking that they want their students to acquire. As teachers reflect on their own learning processes and recognize their own struggles to learn and apply new knowledge, they increase their empathy and understanding for the students' learning processes.

The four categories of analysis described in section IV - (a) cooperative/collaborative learning, (b) integration of curricula, (c) responsibility for learning, and (d) goals and vision for learning - appear to be ones that are generic enough to use in many curriculum reform situations. A school or school team could develop a conscious pattern of such reflection to deepen the nature of the learning community.

Other ways of analyzing the learning process could also be used. For example, Hall and Hord (1984) analyze teachers' adoption of new teaching practices (a teacher learning process) using the stages of concerns that teachers go through in the adoption process. Use of this tool is very informative and could be used by teachers as they consider the stages students go through in their learning process.

Reallocate teacher responsibilities. Teachers at Rockview have more shared planning time than is typical for many high schools and yet it is insufficient for doing the depth of development of the curriculum that is needed for this approach to curriculum reform. The analyses in the preceding section illustrated the number of different dimensions of change that are involved in curriculum reform of this type. Working through these issues requires considerable time.

Yet time per se does not appear to be the true factor. We found that teachers actually had time made available to them administratively that they did not use because it required them to be gone from their classroom when students are present. Conversations with teachers indicate that behind the issue of time is actually a more fundamental one -how teachers perceive their responsibilities. Teachers typically see their classroom responsibilities as far and away the most important. Even the language used when teachers spend a day working on curriculum - "released time" -reinforces this perception. These activities are seen as something that is to be done "in addition to" one's "regular" responsibilities and at best are treated as something temporary that needs to be done maybe for a year or two; then teachers can go back to their classroom responsibilities full time.

The type of reform underway here, where learning and content are dynamic and evolving, requires that teachers engage continually in their own new learning and development of new curriculum along with their classroom responsibilities. New norms that establish a more complex mix of teacher responsibilities appears in order, the specifics of which need to be crafted for the given situation.

Support collective and in-depth professional development. The Rockview team's professional development took place largely in their interactions with one another and other teachers in the school. When they did go outside the school to attend workshops, the attendance tended to be by individual teachers and the content tended to be of a fairly introductory nature.

What seemed particularly missing for the teachers to push to greater levels of quality in their curriculum were blocks of time where teachers worked together to move to more in-depth understanding and development of curriculum. The work thus far on the rubric was a prime illustration of the lack of collective in-depth work by the teachers. A few teachers had gotten an introduction to the concept, had involved a few more teachers and drafted a version of a rubric. Although the teachers quickly realized that it needed major improvement, there were neither norms nor ready mechanisms to analyze and rework the rubric.

Professional development approaches that move teachers to deeper levels of understanding of the new teaching and learning techniques and philosophies seem to be the next step. As noted above, the knowledge of new practices that teachers at Rockview are acquiring is typically introductory, and they do not have mechanisms in place to push to deeper levels of understanding before applying new techniques. To promote such professional development, teachers may wish to engage in study groups, working with outside experts/practitioners in designated areas. They will likely need to work out ways to have blocks of time for certain curriculum development activities and have timeliness that explicitly designate times for piloting new practices, strategies for refinement, and then regular use in the classroom.

Another aspect of teacher learning has to do with the content of the subject areas in the Core. If the teachers are to achieve rich inter-disciplinary content, they need to have reasonable depth of knowledge in each of the content areas involved, as well as an understanding of the intersection of the disciplines and the themes.

Although we have identified this topic as "professional development," it may well be that as teacher responsibilities are reallocated, a new term may be devised that better embedded this type of work in the regular life of a learning community.

Highlight meaningfulness and quality of student work. When one puts together the findings about goals for student learning, the curricular content, the nature of student work, and the status of assessment presented in Section IV, one finds two fundamental and connected themes. It appears that when working on any of these aspects of curriculum reform, it is essential that the work is meaningful to students and that they understand and have incentives to do quality work. The current movement toward projects as the basis for instruction and/or assessment is headed in the right direction but if the projects are not meaningful to students they are unlikely to carry out the tasks at a higher level of quality than they responded to worksheets and paper and pencil tests.

The strength appears to come in the combination of projects that are meaningful and scoring approaches (rubrics) that make clear what constitutes work at different levels of quality. It may well be that the rubrics need to be supplemented with examples of work done at different levels of quality rather than relying simply on verbal descriptions. The old "picture is worth a thousand words" phenomenon comes strongly into play here. Just as teachers have a very difficult time using a teaching technique that they have not seen demonstrated, so too students have a very difficult time carrying out a project when they do not have a mental image of examples representing differing levels of quality. Such examples also address the issue of clarity about the learning goals for students. In some cases what students are to know, be able to do, and be like may be well stated in words whereas in other cases, examples are a better communicator.

Summary. For over five years, Rockview has been reforming toward higher learning and thinking for students. The teachers and administrators have made major strides in changing certain curricular and organizational design features of the school. The daily realities of school life, the norms of the education system, and the perspectives of the community make change a long process. The school now has in place a number of features that span the range of changes that need to be made—content, goals, roles of students and teachers, student work, organization, learning opportunity for teachers. This gives them the general scope of what they need to address. The challenge they now face is how to move beyond superficial changes to the depth that is needed to move students to a deeper and more significant level of learning.

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APPENDIX A: [ROCKVIEW] HIGH SCHOOL BELIEF STATEMENTS
(Revised--Spring, 1998)

We believe that LEARNING at [Rockview] High School should:

1. Be the top priority of all school experiences.
2. Be a life-long process that promotes possibilities, choices, and appreciation for learning.
3. Emphasize critical thinking skills, problem solving, decision making, and creativity.

We believe that LEARNERS (staff, students, and parents):

1. Are unique, with different needs, learning styles, learning rates, and levels of success.
2. Should respect the environment and all people.
3. Have the responsibility for learning and for realizing their own potential.
4. Have obligations in addition to school.
5. Are impacted by life experiences.

We believe that he CURRICULUM at [Rockview] High School should be designed to develop the whole person and include all the experiences under the influence of the school. In addition, it should:

1. Provide challenges for every learner.
2. Not track learners into narrowing experiences.
3. Enhance the self-concept of the learner.
4. Reflect the needs of the students, parents staff, and community.
5. Offer diversification and integration around a common set of learnings (cultural, scientific, personal development, aesthetic, technical, social, civic, future, career.)
6. Emphasize common skill development across many content areas building on the skills learners have already developed.
7. Actively involve learners in its planning and process.
8. Provide open-ended experiences and application beyond the school day and school setting.
9. Promote civic responsibility.
10. Include diverse methods and materials for learning.
11. Reflect district level goals.

We believe that INSTRUCTION at [Rockview] High School should:

1. Encourage staff to establish a learning environment:
    a. That allows some form of success for all learners.
    b. That allows learners to feel good about themselves in the process of learning.
    c. That is challenging to every learner.
    d. That helps in the development of the whole learner including cognitive, affective, and physical aspects.
2. Be characterized by team planning, team teaching, and team learning.
3. Be characterized by learner-centered classrooms (e.g., using cooperative learning techniques, student tutors, and peer tutors).
4. Include opportunities for building-based staff development and professional growth (e.g., peer observation, per coaching).
5. Utilize school/community members as resources for learning.
6. Emphasize the role of the teacher as a facilitator of learning rather than as a dispenser of knowledge.
7. Emphasize the process of learning as well as the content of the particular course.
8. Allow for and not inhibit the learners' humanness and individualism.

We believe that the ORGANIZATION, FUNCTION, AND OPERATION of [Rockview] High School should include:

1. Reflect varied staffing opportunities for all employees of the school.
2. Encourage professional growth for the staff and include time during the day for staff development.
3. Include flexible scheduling based on the needs for curriculum and instruction.
4. Involve staff, students, parents, and the community insetting school policies, hiring, student discipline, and rules of conduct.
5. Reduce age and grade level distinctions for students.
6. Reflect an organization based on interdisciplinary teams rather than subject matter groupings of teachers.
7. Include a centralized word processing area.
8. Include time during the day for meetings and communication within subject-matter groupings of teachers.
9. Include a plan for rotating team members.
10. Have clearly defined roles and expectations.
11. Include an expectation that all staff will become computer literate.
12. Include an ongoing orientation process for new staff members.
13. Include a student advisory system.
14. Include a variety of groupings of staff members for different functions (e.g., budgetary, scheduling, curriculum planning, supervision).
15. Be well-planned and efficient.
16. Provide for a psychologically and physically safe environment.

We believe that the EVALUATION PROCESS at [Rockview] High School has as its goal the improvement of instruction, the person, and the school. Also, it should:

1. Be an ongoing process for all school activities, practices, policies, and learners.
2. Involve representatives of the school-community (students, staff, parents, and community).
3. Use a variety of approaches (e.g., written, verbal, observation, and self-evaluation, emphasizing both formal and informal techniques).
4. Provide a clear understanding of the criteria involving a regular process for reporting progress.

APPENDIX B: THE NINE COMMON PRINCIPLES OF RE:LEARNING[1]

1. The school should focus on helping adolescents learn to use their minds well. Schools should not attempt to be "comprehensive" if such a claim is made at the expense of the school's central intellectual purpose.

2. The school's goals should be simple: that each student master a limited number of essential skills and areas of knowledge. While these skills and areas will, to varying degrees, reflect the traditional academic disciplines, the program's design should be shaped by the intellectual and imaginative powers and competencies that students need, rather than necessarily be "subjects" as conventionally defined. The aphorism "Less is More" should dominate: curricular decision should be guided by the aim of thorough student mastery and achievement rather than by an effort to cover content.

3. The school's goals should apply to all students, while the means to these goals will vary as those students themselves vary. School practice should be tailor-made to meet the needs of every group or class of adolescents.

4. Teaching and learning should be personalized to the maximum feasible extent. Efforts should be directed toward a goal that no teacher have direct responsibility for more than 80 students. To capitalize on this personalization, decisions about the details of the course of study, the use of students' and teachers' time and the choice of teaching materials and specific programs must be unreservedly placed in the hands of the principal and staff.

5. The governing practical metaphor of the school should be student-as worker., rather than the more familiar metaphor of teacher-as-deliverer-of-instructional-services. Accordingly, a prominent pedagogy will be coaching, to provoke students to learn how to learn and thus how to teach themselves.

6. Students entering secondary school studies are those who can show competence in language and elementary mathematics. Students of traditional high school age but not yet at appropriate levels of competence to enter secondary school studies will be provided intensive remedial work to assist them quickly to meet these standards. The diploma should be awarded upon a successful final demonstration of master for graduation—an "Exhibition." This Exhibition by the student of his or her grasp of the central skills and knowledge of the school's program may be jointly administered by the faculty and by higher authorities. As the diploma is awarded when earned, the school's program proceeds with no strict age grading and with no system of "credits earned" by "time spent" in class. The emphasis is on the students' demonstration that they can do important things.

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[1] The principles are taken from materials provided by the Coalition of Essential Schools.

7. The tone of the school should explicitly and self-consciously stress values of unanxious expectation ("I won't threaten you but I expect much of you"), of trust (until abused) and of decency (the values of fairness, generosity, and tolerance). Incentives appropriate to the school's particular students and teachers should be emphasized, and parents should be treated as essential collaborators.

8. The principal and teachers should perceive themselves as generalists first (teachers and scholars in general education) and specialists second (experts in but one particular discipline). Staff should expect multiple obligations (teacher-counselor-manager) and a sense of commitment to the entire school.

9. Ultimate administrative and budget targets should include, in addition to total student loads per teacher of 80 or fewer pupils, substantial time for collective planning by teachers, competitive salaries for staff and an ultimate per pupil cost not to exceed that at traditional schools by more than 10 percent. To accomplish this, administrative plans may have to show the phased reduction or elimination of some services now provided students in many traditional comprehensive secondary schools.

APPENDIX C: TEACHER PARTICIPANTS IN THE STUDY

Given limited resources for the study, it was apparent that choices had to be made within the Core for the in-depth look at the classroom activities. The process of determining the focus began by learning about the teacher teams. Interviews were arranged with team members from as many teams as were interested in participating in the study. In some cases all three team members participated in the interview; in others, one or two representatives participated. In all, representatives from five teams were interviewed and showed interest in participating in the research study.

The hour-long interviews elicited information about several important aspects of the teaching and learning processes within each Core. Some of these aspects included:

- Core characteristics peculiar to teachers and students this year.
- The functioning of the three teachers as a team.
- The integration of subjects within the lessons and time block.
- The integration of thinking skills within the curriculum.
- Key elements of teachers' roles with respect to students and learning specific to that team.

A classroom visit was made to each Core and, to the extent possible, to each of the three Core team members. The classroom visits provided reinforcement and clarification of the teachers' operationalization of their philosophies and approaches expressed in the interviews.

Early in the process of sharpening the focus of the study, it was thought that following the implementation of the Core program with three teams of teachers at different levels of teaming would be instructive. However, the complexity of the program, its unique bent when implemented by different teams, and the intricacy of relationships among team members made it apparent that an intensive study of a single team over the course of a single unit would prove the most enlightening approach.

As with all sites, data on student achievement was minimal. Teachers and administrators believed that the approach is positive for students, citing primarily anecdotal information for support. There were increases in CTBS scores over three years, especially in areas of language and study skills.

The aspect of the school selected for study was the American Studies Integrated Core required of all sophomores.

The decision was made to focus on the work of this team and their students while they used the Perspectives Unit which revolved around the Civil War. This six week unit fit well within the time frame of the research study and seemed especially appropriate given the purpose of the study because the teachers were planning to put even greater emphasis than in the past on the use of a culminating activity as the means by which students would display their learning for the unit. The culminating activity was a "Meeting of the Minds" format. Each student was to select a character from the Civil War whom he/she would role play during the culminating discussion - the Meeting of the Minds.

Focus of Attention and Data Collection Methods

When we began we first considered four areas of focus for the research study:

- Assessment.
- Teaching techniques with emphasis on the use of group process, integration of the content areas and teacher roles.
- The incorporation of art into the thematic units.
- Student empowerment for learning.

The sources of information to inform these research areas included teacher planning, classroom activities and/or products, and student perceptions. The information on these areas was collected via observation and taping of teacher planning meetings, observation of classroom activities, video and audio taping of selected student presentations, collection and review of student assignments and interviews with teachers and students.

Teacher Planning Data Collection

To study the planning of the Perspectives Unit, researchers attended and audio taped the first major planning sessions for the unit. It was the team's custom to plan a week in advance for calendar purposes, but the time and day for planning varied in accordance with individual schedules. The need for longer and more frequent planning for delineating a successful culminating activity to this unit in combination with the variable weekly planning led to a research approach of having the teachers audio tape their planning meetings when and where they occurred.

Collection of Student Work and Classroom Interactions

All classroom activities directed at the development of the Meeting of the Minds culminating activity were observed. These included the unit's introductory block, the assignment of the culminating activity, several small group meetings in preparation for the Meeting of the Minds and, of course, the Meeting of the Minds itself.

Classroom activities in all three subject matter areas were sampled for their specific subject matter emphasis and knowledge-base development, integration with the other subject areas, and future incorporation of this information into the Meeting of the Minds format. Calendars of assignments, class handouts and other miscellaneous materials were collected during the classroom observations.

Student products from classroom activities—small group discussions (via audio taping), individual and group written and art work, and individual and group presentations--were sampled. The students who provided access to their work for this research were chosen by the Core teachers as representing one of five types of students: (1) academically talented, (2) special education, (3) socially adjusting to high school and/or Core, (4) developing personal potential at a rate to have met their potential by the end of the school year, and (5) average among this year's Core students. Three students of each of these types were selected. The three were selected to represent a mix of interest and ability in regard to the mode of communication used for their products—written, artistic or oral. Written, artistic and oral communication products of these students were collected during the course of the unit. Some of these items were preparatory to the Meeting of the Minds; others were specific to individual subject area material.

Additionally, quarter portfolios for six students were tracked over three marking periods. These students were also chosen by the teachers to represent the qualities named above. One additional student--an academically average or "C" student was also tracked for portfolio work. Unit and quarter grades for all the targeted students were also collected.

Student and Teacher Interviews

In addition to collecting student work, the fifteen students targeted for the unit's work were interviewed within two weeks of completion of the unit for their perceptions of the unit specifically and the Core generally. To enrich this information six students from the core's 1991-1992 class were also chosen to be interviewed. These students demonstrated the same qualities listed above.

In addition to initial interviews with the Core teachers, one teacher, representing himself and the Core team, was interviewed individually about three weeks into the unit. All three teachers participated in a group interview at the conclusion of the unit.

APPENDIX D: PERSPECTIVES UNIT

Following is a listing of additional topics for the Perspectives Unit and options for composition, thinking skills and community awareness.

US History

- Causes of the Civil War
- Reconstruction
- Economics and technology
- Total war concept
- Review of 1700s to 1865
- English
- Transcendentalists - Emerson, Thoreau, *The Island* (Paulson)
- Realism vs. Romanticism - *Huck Finn*, *Occurrence at Owl Creek Bridge*, *Red Badge of Courage*, Frederick Douglas, Emily Dickinson, Melville (*Shiloh*), Whitman
- *Autobiography of Miss Jane Pittman*, *Roots* (Haley), *Andersonville*

STS Science

- Organ transplants, donor shortages
- Medical ethics
- Immune system, AIDS
- Blood typing
- Heart dissection
- Physiology of circulatory system
- Medical history
- Artificial organs
- Healing process

Fine Arts

- Matthew Brady photo selections
- Medical illustrations (artist and body)
- Pinhole (challenge)
- Slides on impressionism and post impressionism
- Winslow Homer
- Cowboy and western art
- Folk art - pottery and quilting
- Floaters
- Composition
- Analysis of Sherman's March
- Coop learning - disease research/writing project
- Personalizing the Civil War (Quate)

- Abolitionist editorials
- Opinion writing - organ transplants
- Civil War newspaper
- Create a diary for a soldier, a woman, or a slave

Thinking Skills

- Use of primary sources in historical research
- Timeliness
- Connecting events of past to the present

Community Awareness

- Guest speakers - Organ transplants, Lions Eye Bank
- Civil War Reenactment by professionals

APPENDIX E: RUBRICS

The general rubric given to students at the beginning of the year is shown in Figure 3. The rubrics for the faction, novel project, and book talks are given in this appendix.

Faction Rubric

Novice (knowledge and comprehension).

Integration. Faction includes references to two of the subject areas:

- English - references to the authors or to events in the readings, OR story is realistic, regional, or romantic (not as in love!)
- Science - technology or anatomy references
- History - historical events or characters

Story

- The plot is centered on an event of the Civil War
- The protagonist clearly faces a conflict which a character of this era might have faced
- The setting is accurate

Conventions of Language and Quality of Final Product

- A few mistakes in spelling, punctuation, and capitalization
- A few errors in language use
- The final story is neat

Creativity

- The story was interesting to read, holding the reader's attention most of the time
- The story was predictable
- The characters were very familiar

Intermediate (Application and Analysis)

Integration

- Faction includes content from all three subject areas
- Some of the language studied fits into the story (history: terms; English: dialect; Science: terms)

Story

- The conflict is developed throughout the story
- The dialogue of the characters is realistic and moves the story along
- The story takes place in a short amount of time—it is focused
- The point of view is consistent

Conventions of Language and Quality of Final Product

- Very few mistakes in spelling, punctuation, and capitalization
- A few errors in punctuating dialogue
- The final product is either typed or word processed

Creativity

- The story was interesting to read with some surprises
- The characters were unusual

Expert (Synthesis and Evaluation)

Integration

- Faction includes content from all subject areas in a way that makes sense to the plot
- The facts which form the basis for this story are accurate and clearly enrich the story

Story

- The plot of the story is crafted in an intriguing manner, making the story fun to read
- The characters are developed through dialogue and description
- The setting is detailed and clearly an integral part of the story

Conventions of language and quality of final product

- No mistakes in spelling, punctuation, and capitalization
- No errors in dialogue
- The final product looks professionally done

Creativity

- The story was captivating because of the unusual plot and characters
- The language was crafted well with even a metaphor here or there

Novel Project Rubric[2]

Excellent (18-20). Reflects the characters, setting, theme, and plot of the novel; clearly provides insight into the Civil War; creative and thoughtful; title, author, and student name clearly on the front; very neat; completed on time.

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[2] Research Note: Students were given the option of creating a quilt, mandala, or novel map for the Novel Project. However, it is difficult to apply the rubric to the mandalas. They are so symbolic that it is difficult to draw out the setting, theme, and plot of the novel and especially any insight into the Civil War. Also, because the mandalas were developed around the protagonist, it was difficult to see the connection to the setting, theme, and plot.

Good (16-17). Reflects three of the following: character, setting, theme, plot; gives some insight into the Civil War; thoughtful; title, author, and student name on front; neat; completed on time.

Acceptable (14-15). Reflects two of the following: character, setting, theme, plot; includes reference to the Civil War; title, author, and student name on front; completed on time.

Book Talks Rubric

Excellent (18-20). Holds audience's attention; between two-three minutes; told from first person point of view; book talk is well practiced; tells a bit about the author; just enough of the plot is told to tease the audience into wanting to read it; presenter has read the novel; VERY original and creative.

Good (17-20). Mostly holds audience's attention; the time is a little short or a little long; told from first person point of view; book talk has been practiced a bit; the author's name is mentioned; either too much plot is told or not enough so the audience isn't teased into reading the novel; presenter has read the novel; creative in spots.

Acceptable (14-15). The time in not even close to the two-three minute requirement; book talk seems unpracticed; not told from the first person point of view; the audience isn't pulled in because the presenter seems bored by the book; presenter has read the novel.